OIL·SHALE·TRACT·C-b

ENVIRONMENTAL BASELINE PROGRAM

NOVEMBER '74- OCTOBER '76

FINAL REPORT

METEOROLOGY, AIR QUALITY, AND NOISE

VOLUME 3

C-b SHALE OIL VENTURE • ASHLAND OIL, INC.
OCCIDENTAL OIL SHALE, INC., OPERATOR

U. S. DEPARTMENT OF THE INTERIOR

PROTOTYPE OIL SHALE LEASING PROGRAM

OIL SHALE TRACT C-b

ENVIRONMENTAL BASELINE PROGRAM

FINAL REPORT

(November 1974 Through October 1976)

VOLUME III

METEOROLOGY, AIR QUALITY, AND NOISE

Submitted to:

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By:

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SUMMARY

This report summarizes air quality, meteorology, and noise aspects of the Environmental Baseline Program conducted on the C-b Federal Lease Tract in the Piceance Basin north of Rifle, Colorado during the period from November 1, 1974 through October 31, 1976.

The meteorological program was conducted utilizing a two-hundred-foot instrumented meteorological tower and other measuring instruments. A study of wind fields has been undertaken to determine how they would affect transport and diffusion of pollutants. Wind persistence by atmospheric stability class is an essential input to diffusion models. Winds in the vicinity of the Tract are influenced by both large scale synoptic effects and small-scale local terrain effects with the latter usually more important. Patterns are diurnal in nature with flows downhill and down-creek at night and uphill, up-creek in the day with chaneling by valley walls a major influence. Flows in general are neither uniform nor straight. Predominant wind direction on Tract at the tower is south-southwest. Peak 5-minute wind speeds have reached the 56-60 mph range only twice at the two hundred foot level in two years; the probability that a 5-minute gust will exceed 40 mph is 1.8×10^{-4}. Vertical wind structure is often far from uniform in direction; it generally increases in speed as height increases. On one occasion during tethersonde tests southerly winds at tower level have changed to calm between 700-1100 ft. and completely reversed direction to northwesterly above that level.

Annual temperature ranges of 150°F have been achieved at the Tract, from about 100°F highs in the summer to -50°F in the winter. Inversions formed at night due to intense radiational cooling. They occurred on most days in the vicinity of the Tract usually starting in the early evening and dissipating by mid-morning; inversions were stronger in Piceance Creek than on Tract. They often occurred to heights of 1000-1200 ft above the Tract surface; mean inversion height at the tower was 723 feet. Inversion durations were longest in winter (13-14 hours) and shortest (5-8 hours) in summer. Strong horizontal temperature gradients (17 degrees in 4 miles) have been noted in Piceance Creek in the presence of inversions, particularly when the inversion has started to lift at one locale but is still strong at the other end of the horizontal strip.

Atmospheric stability has been derived primarily by tower incremental temperature techniques, characterizing low level pollutant releases. Class D (neutral stability) occurred most frequently. Highest percent of stable class F (29 percent in '75; 21 percent in '76)

occurs in late summer to early fall. Stability assessment characterizing high altitude pollutant releases (600-1000 ft.) have been made on a selective basis utilizing aircraft and tethersonde data. Only during the summer quarter of aircraft sampling did F-stability exist at altitudes up to 1000 feet; the tethersonde did not yield any stability class higher than D at a 600 foot level at the tower on an hourly basis averaged over the test span.

Gaseous concentrations have been monitored for sulfur dioxide, hydrogen sulfide, total hydrocarbons, methane, non-methane hydrocarbons, carbon monoxide, oxides of nitrogen, and ozone. Also suspended particulate concentrations have been monitored. Average background concentrations of all gases are fairly low; infrequent high concentrations can occur. Readings in excess of standards have occurred for particulates and non-methane hydrocarbons. One ozone reading was equal to the standard. Some high ozone readings have been shown to correspond with either frontal passages during which ozone from the stratosphere is mixed downward or long distance transport from urban centers (Las Vegas, Salt Lake City) or both and others to local sources. Particulates at the C-b Tract are primarily of fugitive origin. This was reasoned from the facts that high particulate loadings correlated best with maximum daily wind speed and that the 24-hour peak-to-annual-mean particulate ratios at the Tract were shown to be 3-4 times higher than ratios measured at an urban non-fugitive particulate station. The mass density of particulates in the respirable range has been shown to be approximately log-normally distributed. It has been shown that most particulates at the Tract are of sizes larger than respirable.

Trace elements in suspended particulates have been studied by spark-source mass spectroscopy and volatile trace elements (selenium, mercury, particulate arsenic, and arsine) were studied by special chemical methods. Low levels are indicated in practically all instances. Some difficulty was encountered in measuring arsine (AsH_3), particularly during the first year, due partly to the interaction with particulate matter; the second year particulate arsenic was determined separately and arsine concentrations were estimated to be below 0.5 $\mu g/m^3$.

Area wide visibility measurements were made every sixth day for one year. Mean visual range was 79 miles; 95 percent of the measurements exceeded 41 miles. Daily mean visual ranges exhibited large fluctuations, especially in fall and winter; variations of 30 to 40 miles were common. A statistical correlation study of visual range with other parameters yielded the result that relative humidity correlated best with ozone being the second most important parameter.

A Piceance Basin traffic noise study indicated that highway I-70 east and west of Rifle proved to be noisiest with a sound level of 66 dbA exceeded 10 percent of the time; three sampling stations along Piceance Creek road were the quietest sampling locations with only 53 dbA exceeded 10 percent of the time. For the most part the Tract has been quiet.

Baseline "experience" has been used to provide guidance to the environmental monitoring program as set forth in Chapter 4, Program Utilization. Other areas of application and assistance include specification of environmental criteria for structural design and provision of inputs for air diffusion models. Identification of both new or continuing data requirements for the monitoring phase and of parameters to satisfy these requirements are made. Performance "attributes" of baseline instrumentation are included as part of this discussion so as to recommend either continuing use or replacement.

As far as the total air quality, meteorology, and noise programs are concerned, the Environmental Baseline Program complies with all requirements of the lease.

1 INTRODUCTION

Any studies of environmental impacts must compare the "after" with the "before". The Prototype Oil Shale Leasing Program is designed to compare the before and after over its entire course. Lease requirements for this program as tailored specifically to the C-b Tract require a two year field study prior to Tract development called an Environmental Baseline Program. This baseline program on the C-b Federal Lease Tract in the Piceance Basin north of Rifle, Colorado was conducted from November 1, 1974 through October 31, 1976. This is Volume III of a five volume set which summarizes this two year program. This volume summarizes air quality, meteorology, and noise field studies at the Tract.

The lease stipulates that air quality be monitored over the entire lease year at four locations for sulfur dioxide, hydrogen sulfide, and suspended particulates using continuous recorders where applicable. The Lessee is also required to monitor hydrocarbons, oxides of nitrogen, and other pollutants. The Lessee is also required to establish a meteorological tower with multilevel instrumentation for measurements of wind speed and direction, relative humidity, and temperature. Subsequent conditions of approval imposed by the Area Oil Shale Supervisor, who administers the Prototype Oil Shale Leasing Program in the Department of the Interior, required that upper air studies of temperatures and wind profiles, visibility studies and noise studies be conducted. Initial lease requirements, modified during baseline, required operational performance efficiency of 90 percent for air quality and 95 percent for meteorology.

To satisfy the conditions of the lease and provide additional data, five air quality trailers, a 200-foot meteorological tower, three mechanical weather stations, two acoustic sounders, aircraft, free-flying and tethered balloons, special chemical analyses for trace metals, visibility by photometry and sound-level measurement techniques were utilized. This represents one of the most complete data bases collected to establish a baseline against which to compare potential future changes. All data collected are on file in quarterly data reports in the Area Oil Shale Supervisor's office currently located at 131 N. 6th St.; Grand Junction, Colorado. (Telephone (303) 242-0731, X 281.)

Air quality monitoring is not only required under this lease; it is also required under Federal and State of Colorado regulations. Several air quality permits are required during the course of operations; examples include a permit to construct the facility and

to emit specified pollutants. The permit to construct requires computer modeling of shale-plant pollutant diffusion parameters to demonstrate compliance with prevention-of-significant-deterioration regulations for both sulfur dioxide and particulates. These regulations are so stringent that no significant air pollution impacts can occur.

Chapter 2, Program Description, of this report details pertinent lease stipulations and conditions of approval. It describes relevant standards and regulations to help place the monitoring of potential pollutants in perspective. It also presents a description and purpose of the air quality, and meteorological and noise sampling networks, and the data sampling frequencies and spans.

Chapter 3, Baseline Programs, presents a rather large, detailed, descriptive summary of programs in each area:

Meteorology - wind fields, temperature fields, and other meteorology

Air Quality - gaseous concentrations, particulate concentrations, side-by-side tests of SO_2 and H_2S, ozone transport analysis, comparisons of background levels with standards, trace elements, and visibility

Noise - Piceance Basin traffic noise, environmental baseline noise.

Major program discussions in this chapter are organized by 1) rationale, 2) objectives, 3) experimental design, 4) summary of the methodology, and 5) results and discussion. Details of both methodology and quality assurance considerations are presented in depth in Appendix A. The presentations of voluminous data charts and figures are relegated to Appendix B so as not to detract from descriptive summary in the text.

Chapter 4, Utilization, is directed toward highlighting and projecting the utility of the baseline program. It covers structural design criteria and air- and noise-related monitoring program guidelines. Structural design criteria include estimates of environmental extremes measured in baseline (wind, temperature, snow loads, frost depths, lightning frequency, etc.). In some cases additional techniques are utilized to estimate peaks for different event return periods (severe storms and peak winds). Monitoring program guidelines include program design criteria and specific relationships of Baseline to the Environmental Monitoring phase.

References are cited following Chapter 4. Next follow the previously mentioned appendices and a glossary of words used in this volume. An English-metric conversion-of-units table is presented in Appendix B for convenience.

2.1 Lease Requirements and Stipulations

The rather involved set of events which initially established and periodically revised the requirements for the air quality and noise environmental baseline programs are portrayed on Figure 2-1.

In March 1974, the lease was signed for the Prototype Oil Shale Leasing Program and a Preliminary Development Plan for Tract C-b was submitted by the Lessees to the Area Oil Shale Supervisor (AOSS). The lease contains Environmental Lease Stipulations specifically with regard to air quality; these are included in Table 2-1. Later in May 1974, the Environmental Monitoring Program addressed in the Preliminary Development Plan was amplified in a document called a Supplemental Exploration Plan into two phases: Pre-Exploration Environmental Investigation and Environmental Baseline Monitoring Programs. Conditions of Approval (COA) to the Supplemental Exploration Plan were set forth for air quality in July 1974; a revision to the COA was issued in January 1975.

The Environmental Baseline Monitoring Program for air quality was initiated on November 1, 1974, and continued for two years through October 31, 1976. During this time period, the Lease Environmental Stipulations were revised twice with respect to air quality; these revisions are discussed in Sub-section 2.1.1. Also during the Environmental Baseline Monitoring period, the following actions occurred which further implemented the program:

* In April 1975, approval was given by the AOSS for a long-range visibility program (Section 2.2);

* In August 1975, a noise-studies program was initiated (Sub-section 2.1.2);

* In November 1975, approval was given by the AOSS to discontinue upper air soundings and trace element analyses (Section 2.2);

* In December 1975, approval by the AOSS was given to conduct side-by-side tests for H_2S and SO_2 (Section 2.2).

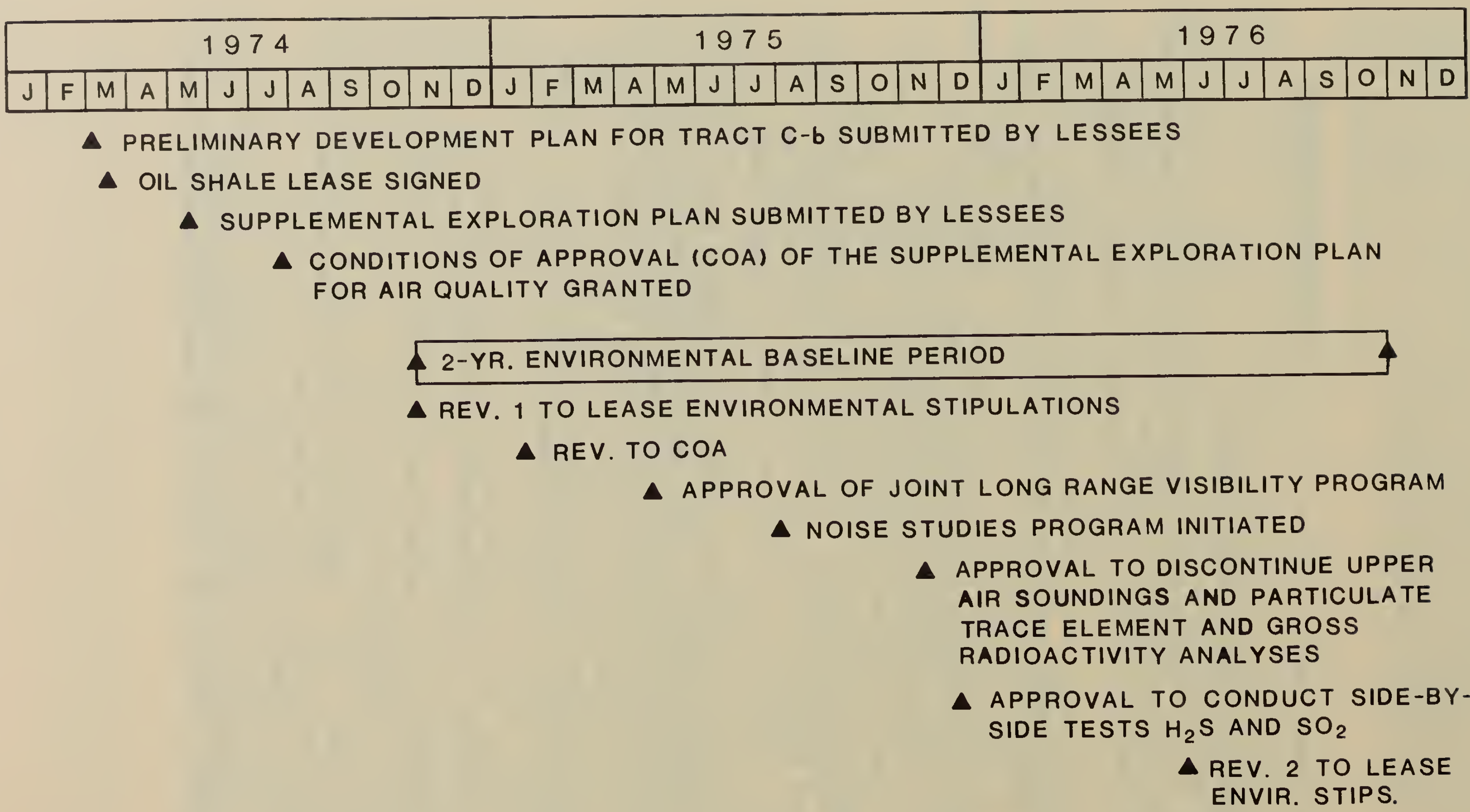


FIGURE 2-1 TIMETABLE OF EVENTS RELATED TO ENVIRONMENTAL BASELINE REQUIREMENTS FOR AIR QUALITY

Table 2-1 LEASE ENVIRONMENTAL STIPULATIONS RELATED TO AIR QUALITY (Section 1(C)(2)(c))

(c) Air Quality. In the collection of baseline data, the Lessee shall monitor air quality over at least 90 percent of each lease year, during which monitoring is required, using four strategically-located stations. One of the stations shall be at the expected point of maximum concentrations, or as close to that expected point of maximum concentrations as feasible.

The Lessee shall monitor air quality for sulfur dioxide, hydrogen sulfide, and suspended particulates, using automatic instruments with continuous recorders, when applicable. The Lessee shall also monitor, under the same conditions, hydrocarbons, oxides of nitrogen, and other pollutants, where the Mining Supervisor has determined that such monitoring is necessary to determine baseline air quality or to conduct an effective monitoring program. In addition, the Lessee shall establish a meteorological station in reasonable proximity to each proposed plant site to monitor, at least 95 percent of the time over each lease year during which monitoring is required, wind direction and speed (vane and anemometer) and humidity at three levels, one at least 100 feet above the surface of the plant site, one at approximately 30 feet above the surface of the plant site, and one at ground level, and temperature at two levels, one at least 100 feet above the surface of the plant site, and one at approximately 30 feet above the surface of the plant site. The Lessee shall maintain records of all baseline data collection and monitoring programs.

2.1.1 Air Quality and Meteorology

To satisfy the conditions of the lease, five air quality stations (trailers) were utilized during the baseline period; at three of these locations sulfur dioxide, hydrogen sulfide, and particulates were continuously monitored. At the remaining two locations, additionally, the oxides of nitrogen, total hydrocarbons, non-methane hydrocarbons, methane, and carbon monoxide were continuously monitored. Ozone was also continuously monitored although not initially required.

To satisfy the lease requirements for meteorology, a 200-foot meteorological tower was utilized. It was instrumented at each of four levels (8 ft., 30 ft., 100 ft., and 200 ft.) for wind speed and direction, temperature, and relative humidity.

It is to be noted that the lease required an operational performance efficiency of 90 percent for air quality and 95 percent for meteorology.

The Environmental Lease Stipulations have been twice modified with respect to air quality and meteorology as indicated on Tables 2-2 and 2-3. The initial change on October 31, 1974 merely lowered the relative humidity measurement location requirement from three levels to only one level on the tower. The second amendment was a major change which deleted the operating efficiency requirement, effective June 1, 1976, and added ozone as a required atmospheric constituent to be measured. (It has always been measured at two locations.)

Regarding achievement of the operating performance requirements Tables 2-4 and 2-5 present operating efficiencies by month, by constituent, monthly cumulatives, and the cumulative composite averaged over all gaseous and particulate constituents and over all meteorological parameters. The meteorology cumulative composite met the 95 percent requirement over the 19-month period (through May 1976) for which it governed. The air quality cumulative composite met the 90 percent requirement over the 19-month period for which it governed.

2.1.2 Noise

Background measurements of noise in the vicinity of the Tract were not required by the Lease. At the request of the AOSS, a noise program was initiated in August 1975 for which measurements were made at 14 locations on the Tract and roads leading to the Tract on a monthly basis.

Table 2-2 AMENDMENT DATED OCTOBER 31, 1974
TO THE LEASE ENVIRONMENTAL STIPULATIONS
RELATED TO AIR QUALITY

AMENDMENT OF OIL SHALE LEASE

LEASE NUMBER C-20341, TRACT C-b

Pursuant to Section 1 (B) of the Oil Shale Lease Environmental Stipulation which sets forth procedures for changing environmental stipulations, the parties to this document have agreed to revise the stipulation contained in the second paragraph of Section 1(C)(2)(c), Air Quality, to read as follows:

> The Lessee shall monitor air quality for sulfur dioxide, hydrogen sulfide, and suspended particulates, using automatic instruments with continuous recorders, when applicable. The Lessee shall also monitor, under the same conditions, hydrocarbons, oxides of nitrogen, and other pollutants, where the Area Oil Shale Supervisor has determined that such monitoring is necessary to determine baseline air quality or to conduct an effective monitoring program. In addition, the Lessee shall establish a meteorological station in reasonable proximity to each proposed plant site to monitor, at least 95 percent of the time over each lease year during which monitoring is required, wind direction and speed (vane and anemometer) at three levels, one at least 100 feet above the surface of the plant site, one at approximately 30 feet above the surface of the plant site, and one at an intermediate level, and temperature at two levels, one at least 100 feet above the surface of the plant site, and one at approximately 30 feet above the surface of the plant site, and humidity at one level. The Lessee shall maintain records of all baseline data collection and monitoring programs.

ATLANTIC RICHFIELD COMPANY

By____________________
Vice President

____
Peter A. Rutledge
Area Oil Shale Supervisor
U. S. Geological Survey

ASHLAND OIL, INC.

By____________________
Vice President

____
Marvin W. Pearson
District Manager
Bureau of Land Management

SHELL OIL COMPANY

By____________________
Vice President

THE OIL SHALE CORPORATION

October 31, 1974
Effective Date

By____________________
Vice President

Table 2-3 AMENDMENT DATED JUNE 1, 1976
TO THE LEASE ENVIRONMENTAL STIPULATIONS
RELATED TO AIR QUALITY

AMENDMENT OF OIL SHALE LEASE

SERIAL NUMBER C-20341

Tract C-b

Pursuant to Section 1(B) of the Oil Shale Lease Environmental Stipulation which sets forth procedures for changing environmental stipulations, the parties to this document have agreed to revise the stipulation contained in Section 1(C)(2)(c), Air Quality, to read as follows:

(c) Air Quality and Meteorology.

(1) The objectives of the Air Quality and Meteorology monitoring program are to define the existing environment as a baseline against which to compare future changes, define meteorological factors which might influence the transport and diffusion of pollutants which might be emitted by sources on or near the Tracts, identify the meteorology of the area for detailed planning purposes, monitor impacts of lease development and operation on air quality, determine source and magnitude of plant emissions, and provide information for plant operation to minimize impacts of future facility operations.

(2) In the collection of baseline data to meet the above stated objectives, the Lessee shall record air quality, using strategically-located stations. The number and location of stations shall be recommended by the Lessee and approved by the Mining Supervisor. One of the stations shall be located as close to the expected point of maximum concentration as feasible. Once established pursuant to this stipulation the number and location of such stations shall not be changed except by mutual consent of the Mining Supervisor and Lessee.

(3) The Lessee shall collect air quality data for all pollutants that the Mining Supervisor determines are necessary to establish baseline air quality, including but not limited to sulfur dioxide, hydrogen sulfide, suspended particulates, hydrocarbons, oxides of nitrogen, ozone, and carbon monoxide.

(4) In addition to the stations required by paragraph 2(c)(2) of this Subsection (c), the Lessee shall establish a meteorological station in reasonable proximity to each proposed plant site to record wind direction and speed (vane and anemometer) at two levels, one at least 30 meters above the surface of the plant site, one at approximately 10 meters above the surface of the plant site, and temperature at two levels, one at least 30 meters above the surface of the plant site, and one at approximately 10 meters above the surface

of the plant site, and humidity at one level. An upper air data collection program shall be implemented as deemed necessary by the Mining Supervisor for the purpose of obtaining information for diffusion modeling.

(5) The Lessee shall establish a monitoring program. To assist in the identification of pollutants to be monitored, the Lessee shall submit to the Mining Supervisor a detailed description of emissions anticipated during the development of the Leased Lands and Leased Deposits. The Lessee shall also monitor source emissions at locations approved by the Mining Supervisor.

(6) In the design and operation of the baseline data collection and monitoring programs, the Lessee shall strive to collect data for the greatest period of time practicable with emphasis on acquisition of quality data. The Lessee shall establish and implement a quality assurance program approved by the Mining Supervisor to assure high quality data collection. This quality assurance program shall include but not be limited to: quality control by standard reference materials, such as those available through National Bureau of Standards; data validation through established criteria of acceptability; method and frequency of calibration and maintenance; and testing programs to identify and quantify data anomalies.

(7) The Lessee shall maintain records and submit reports of all baseline data collection and monitoring programs. Where practicable, data shall be programmed in a format compatible with a nationally recognized computer data storage and retrieval system.

THE UNITED STATES OF AMERICA

By____________________________
Peter A. Rutledge
Area Oil Shale Supervisor
U.S. Geological Survey

By____________________________
Marvin W. Pearson
District Manager, Bureau of Land Management

ASHLAND OIL, INC.

By____________________________
Vice President

SHELL OIL COMPANY

By____________________________
Vice President

Effective Date: June 1, 1976

Table 2-4

AIR QUALITY AND METEOROLOGY OPERATING EFFICIENCIES FOR 1974-1975

CHANNEL (NO. OF CHANNELS)		MONTH											
		NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.
MONTHLY OPERATING EFFICIENCIES													
Sulfur Dioxide	(4)	99	85	100	100	95	100	98	97	100	100	99	98
Hydrogen Sulfide	(4)	99	89	100	99	99	100	98	97	99	99	98	100
Particulates	(4)	18	62	73	91	88	100	100	97	100	100	99	100
Nitrogen Oxides (NOX)	(1)	100	94	84	82	52	100	100	87	97	100	100	100
Nitric Oxide	(1)	100	94	84	82	52	100	100	87	100	100	100	100
Total Hydrocarbons	(1)	70	81	74	100	90	100	100	97	100	100	100	87
Methane	(1)	70	81	81	68	87	100	100	97	100	100	100	84
Carbon Monoxide	(1)	77	81	84	100	97	100	100	100	100	100	97	71
Ozone	(1)	93	94	100	96	100	100	100	100	100	100	97	100
Composite	(18)	76	82	89	94	89	100	99	96	100	100	99	96
Wind Speed - 30 Feet	(1)	100	65	94	100	77	100	100	87	100	100	100	100
Wind Speed - 100 Feet	(1)	100	65	94	100	77	100	100	87	100	100	100	100
Wind Speed - 200 Feet	(1)	100	65	94	100	77	100	100	87	100	100	100	100
Wind Direction - 30 Feet	(1)	100	65	94	100	77	100	100	87	100	100	100	100
Wind Direction - 100 Feet	(1)	100	65	94	100	77	100	100	87	100	100	100	100
Wind Direction - 200 Feet	(1)	100	65	94	100	77	100	100	87	100	100	100	100
Relative Humidity - 8, 30, 100 or 200	(1)	100	65	94	100	77	100	100	87	97	100	100	100
Temperature - 30 Feet	(1)	100	65	94	100	77	100	100	87	100	100	100	100
Temperature - 100 or 200 Feet	(1)	100	65	94	100	77	100	100	87	100	100	100	100
Composite	(9)	100	65	94	100	77	100	100	87	100	100	100	100
MONTHLY CUMULATIVE OPERATING EFFICIENCIES													
Sulfur Dioxide	(4)	99.0	92.0	94.7	96.0	95.8	96.5	96.7	96.7	97.1	97.4	97.6	97.6
Hydrogen Sulfide	(4)	99.0	94.0	96.0	96.8	97.2	97.7	97.7	97.6	97.8	97.9	97.9	98.1
Particulates	(4)	18.0	40.0	51.0	61.0	66.4	72.0	76.0	78.6	81.0	82.9	84.4	85.7
Nitrogen Oxides (NOX)	(1)	100.0	97.0	92.7	90.0	82.4	85.3	87.4	87.4	88.5	89.7	82.6	84.1
Nitric Oxide	(1)	100.0	97.0	92.7	90.0	82.4	85.3	87.4	87.4	88.8	89.9	90.8	91.6
Total Hydrocarbons	(1)	70.0	75.5	75.0	81.3	83.0	85.8	87.8	89.0	90.2	91.2	92.0	91.6
Methane	(1)	70.0	75.5	77.3	75.0	77.4	81.2	83.9	85.5	87.1	88.4	89.5	89.0
Carbon Monoxide	(1)	77.0	79.0	80.7	85.5	87.8	89.8	91.3	92.4	93.2	93.9	94.2	92.3
Ozone	(1)	93.0	93.5	95.7	95.8	96.6	97.2	97.6	97.9	98.1	98.3	98.2	98.4
Composite	(18)	76.0	79.0	82.3	85.2	86.0	88.3	89.8	90.6	91.6	92.4	93.0	93.3
Wind Speed - 30 Feet	(1)	100.0	82.5	86.3	89.7	87.2	89.3	90.8	90.3	91.4	92.3	93.0	93.6
Wind Speed - 100 Feet	(1)	100.0	82.5	86.3	89.7	87.2	89.3	90.8	90.3	91.4	92.3	93.0	93.6
Wind Speed - 200 Feet	(1)	100.0	82.5	86.3	89.7	87.2	89.3	90.8	90.3	91.4	92.3	93.0	93.6
Wind Direction - 30 Feet	(1)	100.0	82.5	86.3	89.7	87.2	89.3	90.8	90.3	91.4	92.3	93.0	93.6
Wind Direction - 100 Feet	(1)	100.0	82.5	86.3	89.7	87.2	89.3	90.8	90.3	91.4	92.3	93.0	93.6
Wind Direction - 200 Feet	(1)	100.0	82.5	86.3	89.7	87.2	89.3	90.8	90.3	91.4	92.3	93.0	93.6
Relative Humidity - 8, 30, 100 or 200	(1)	100.0	82.5	86.3	89.7	87.2	89.3	90.8	90.3	91.0	91.9	92.6	93.2
Temperature - 30 Feet	(1)	100.0	82.5	86.3	89.7	87.2	89.3	90.8	90.3	91.4	92.3	93.0	93.6
Temperature - 100 or 200 Feet	(1)	100.0	82.5	86.3	89.7	87.2	89.3	90.8	90.3	91.4	92.3	93.0	93.6
Composite	(9)	100.0	82.5	86.3	89.7	87.2	89.3	90.8	90.3	91.4	92.3	93.0	93.6

Table 2-5

AIR QUALITY AND METEOROLOGY OPERATING EFFICIENCIES FOR 1975-1976

CHANNEL (NO. OF CHANNELS)		MONTH											
		NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.
MONTHLY OPERATING EFFICIENCIES													
Sulfur Dioxide	(4)	97	98	98	98	100	100	93	88	95	91	77	92
Hydrogen Sulfide	(4)	98	98	99	100	100	100	91	92	87	83	82	90
Particulates	(4)	96	100	99	100	100	100	96	100	100	98	100	96
Nitrogen Oxides (NOX)	(1)	100	94	81	100	100	97	97	100	97	94	100	87
Nitric Oxide	(1)	100	94	94	100	100	97	100	100	97	97	100	87
Total Hydrocarbons	(1)	97	97	94	93	97	97	81	97	100	94	100	81
Methane	(1)	97	97	94	100	94	90	87	97	100	94	100	81
Carbon Monoxide	(1)	83	29	84	97	90	100	61	80	100	90	100	71
Ozone	(1)	100	94	94	100	100	100	100	100	100	100	100	100
Composite	(18)	97	94	96	99	99	99	91	94	96	92	91	90
Wind Speed - 30 Feet	(1)	100	100	100	100	100	100	94	100	100	97	100	100
Wind Speed - 100 Feet	(1)	100	100	100	100	100	100	94	100	100	97	100	100
Wind Speed - 200 Feet	(1)	100	100	100	100	100	100	94	100	100	97	100	100
Wind Direction - 30 Feet	(1)	100	100	100	100	100	100	94	100	100	94	100	100
Wind Direction - 100 Feet	(1)	100	100	100	100	100	100	94	100	100	94	100	100
Wind Direction - 200 Feet	(1)	100	100	55	100	100	100	94	100	100	94	100	100
Relative Humidity - 8, 30, 100 or 200	(1)	100	100	100	100	100	100	94	100	100	97	100	100
Temperature - 30 Feet	(1)	100	100	100	100	100	100	94	100	100	97	100	100
Temperature - 100 or 200 Feet	(1)	100	100	100	100	100	100	94	100	100	97	100	100
Composite	(9)	100	100	95	100	100	100	94	100	100	96	100	100
MONTHLY CUMULATIVE OPERATING EFFICIENCIES													
Sulfur Dioxide	(4)	97.6	97.6	97.6	97.6	97.7	97.8	97.5	97.0	96.9	96.6	97.7	95.5
Hydrogen Sulfide	(4)	98.1	98.1	98.2	98.3	98.4	98.5	98.1	97.8	97.3	96.7	96.1	95.8
Particulates	(4)	86.5	87.5	88.3	89.0	89.6	90.2	90.5	91.0	91.4	91.7	92.1	92.3
Nitrogen Oxides (NOX)	(1)	85.3	85.9	85.6	96.5	87.3	87.8	88.2	88.8	89.2	89.4	89.9	89.8
Nitric Oxide	(1)	92.2	92.3	92.4	92.9	93.3	93.5	93.8	94.1	94.2	94.3	94.5	94.2
Total Hydrocarbons	(1)	92.0	92.4	92.5	92.5	92.8	93.0	92.4	92.6	93.0	93.0	93.3	92.8
Methane	(1)	89.6	90.1	90.4	91.0	91.2	91.1	90.9	91.2	91.6	91.7	92.1	91.6
Carbon Monoxide	(1)	91.6	87.1	86.9	87.5	87.6	88.3	96.9	86.6	87.2	87.3	87.9	87.2
Ozone	(1)	98.5	98.2	97.9	98.0	98.1	98.2	98.3	98.4	98.5	98.6	98.7	98.8
Composite	(18)	93.6	93.6	93.8	94.1	94.4	94.7	94.5	94.5	94.6	94.5	94.3	94.1
Wind Speed - 30 Feet	(1)	94.1	94.5	94.9	95.2	95.5	95.8	95.7	95.9	96.1	96.1	96.3	96.5
Wind Speed - 100 Feet	(1)	94.1	94.5	94.9	95.2	95.5	95.8	95.7	95.9	96.1	96.1	96.3	96.5
Wind Speed - 200 Feet	(1)	94.1	94.5	94.9	95.2	95.5	95.8	95.7	95.9	96.1	96.1	96.3	96.5
Wind Direction - 30 Feet	(1)	94.1	94.5	94.9	95.2	95.5	95.8	95.7	95.9	96.1	96.0	96.2	96.4
Wind Direction - 100 Feet	(1)	94.1	94.5	94.9	95.2	95.5	95.8	95.7	95.9	96.1	96.0	96.2	96.4
Wind Direction - 200 Feet	(1)	94.1	94.5	91.9	92.4	92.8	93.2	93.2	93.5	93.8	93.8	94.1	94.3
Relative Humidity - 8, 30, 100 or 200	(1)	93.7	94.2	94.6	94.9	95.2	95.5	95.4	95.6	95.8	95.9	96.1	96.3
Temperature - 30 Feet	(1)	94.1	94.5	94.9	95.2	95.5	95.8	95.7	95.9	96.1	96.1	96.3	96.5
Temperature - 100 or 200 Feet	(1)	94.1	94.5	94.9	95.2	95.5	95.8	95.7	95.9	96.1	96.1	96.3	96.5
Composite	(9)	94.1	94.5	94.5	95.2	95.5	95.8	95.7	95.9	96.1	96.1	96.3	96.5

2.2 Conditions of Approval of the Supplemental Exploration Plan

Conditions of approval with respect to air quality were initially issued in July 1974, as presented on Table 2-6 which require sampling for trace elements (Item 1 of Table 2-6), submittal of quarterly data reports (Item 4), a visibility study (Item 5), fixed air quality station locations (Items 6, 7), upper air studies (Item 8), joint frequency distributions for wind speed and direction and for atmospheric stability (Item 9) and solar radiation data collection (Item 10). Approval was later given in November 1975 to discontinue upper air soundings and trace element analysis after four quarters of data collection.

In December 1975, approval was granted to conduct three month side-by-side tests of two identical SO_2 analyzers at one station and two identical H_2S analyzers at a second station.

Table 2-6

CONDITIONS FOR APPROVAL
EXPLORATION PLAN FOR TRACT C-b
METEOROLOGY AND AIR QUALITY PROGRAM

1. Composite samples from one high volume particulate sampler will be analyzed on a quarterly basis for suspended particulates; gross radioactivity; and qualitative screening for the following trace elements, aluminum, antimony, arsenic, barium, beryllium, bismuth, cadmium, calcium, cerium, chromium, cobalt, copper, fluorine, gallium, germanium, iron, lanthanum, lead, lithium, magnesium, manganese, mercury, molybdenum, nickel, osmium, palladium, phosphorus, platinum, radium, rhenium, rhodium, rubidium, ruthenium, scandium, selenium, silver, strontium, sulfur, tin, titanium, thallium, thorium, uranium, vanadium, ytterbium, yttrium, zinc, and zirconium. Quantitative analysis is required if high levels of toxic elements are detected or if beta radiation exceeds 1 pc/m^3 or large jumps in gross radioactivity occur.

2. Those samples obtained from high volume particulate sampling equipment which have not been analyzed shall be stored and retained by the lessee for future reference.

3. Per the lease stipulations, air quality shall be monitored over at least 90 percent of each lease year during which monitoring is required and meteorology monitoring shall be done over at least 95 percent of the time during each lease year that monitoring is required. Instrument calibration time is considered as part of normal equipment operating time in meeting the operating time requirements. Instrument calibration data will be recorded and kept at each monitoring station. A site log will be kept at each station for sign in and to provide an ongoing record of work performed and an operator log will be kept by each operator to record station visits and work performed.

4. Air quality and meteorological data will be submitted to the Area Oil Shale Supervisor within 45 days after the end of each of the following seasonal quarters: December, January, February; March, April, May; June, July, August; September, October, November.

5. Baseline data for site visibility is required with data collection done on a regular and routine basis. Techniques used to monitor visibility must have proven capabilities in range, accuracy, and sensitivity to provide useful data. Where photography is used, techniques and equipment should be standardized to insure use of same camera, lens, filters, film type, processing, etc. Polaroid photographs are not considered to be of sufficient quality for visibility studies. Proposals to use instrumentation for visibility measurements should include manufacturer's specifications. The proposal for visibility studies will be submitted to the Area Oil Shale Supervisor for approval.

6. Air quality station locations at Redd Ranch, Rock School, Oldland Ranch, and on the ridge between Cottonwood and Sorghum Gulches will remain fixed for one year. If data shows that monitoring should be done at different sites, relocation of specific stations may be required by the Area Oil Shale Supervisor.

7. The spare air quality station located at the meteorological station will be utilized to obtain additional background air quality data for comparison with data obtained from the required air quality stations.

8. For upper atmosphere baseline monitoring, two winds aloft and temperature profile measurements per day for a minimum of 15 days per quarter, chosen to be as representative of the season as practical, will be taken to 6,000 feet above ground level. The upper atmosphere testing program is subject to revision by the Area Oil Shale Supervisor pending review of data findings. (1)

9. X/Q estimates should be included for 24-hour and 3-hour averages. Joint frequency distributions of wind speed, wind direction, and stability should be summarized on a monthly basis.

10. Baseline solar radiation data is required. Data collection shall be done at the meteorological tower.

(1) This requirement was subsequently terminated after 1 year of baseline studies.

2.3 Air Quality Standards

2.3.1 Definitions

Air Quality Maintenance Areas (AQMA's) are those areas within a state for which the potential of exceeding the National Ambient Air Quality Standards (NAAQS) exists. They are jointly administered by the State and the EPA. The Colorado Oil Shale Area consisting of Moffat, Rio Blanco, Garfield, and Mesa Counties is one such AQMA.

Ambient standards indicate absolute ambient levels of pollution that cannot legally be exceeded in a specific region.

There are two types:

Primary standards are based on protection of public health;

Secondary standards are based on protection of public welfare.

Background levels are those measured absolute ambient levels which exist prior to any man-made development in an area. Measurements made at the C-b Tract during the two-year environmental baseline period are defined to be background levels.

Emission standards are legal restrictions on the absolute amount or conditions of release of a pollutant from any source (such as a stack, for example).

Type classifications for emission standards include:

Stationary - fixed location, such as industries and utilities;

Mobil - such as automobiles, trains, etc.

Prevention of Significant Deterioration - (often abbreviated PSD and sometimes called non-significant deterioration or non-degradation). These standards apply within areas cleaner than those required by federal ambient air quality standards. They establish pristine areas (Class I) and establish conditions for states to designate remaining clean-air areas which permit moderate

growth (Class II). Allowable increments in ambient concentrations above background levels for sulfur dioxide and particulates are specified by Class. This increment plus the background level must also be less than the NAAQS or the Colorado Ambient Standards, whichever is more stringent.

2.3.2 Applicability

For convenience, the NAAQS, PSD, and Colorado Ambient Air Quality Standards that are applicable to the C-b Tract are summarized in Table 2-7. The two-year environmental baseline period has recorded background ambient levels. PSD regulations and emissions standards pertain to oil-shale-plant-induced changes. Note that the NAAQS are absolute values; those for the State Ambient Standards are incremental values for SO_2 for Categories I and II and are absolute for Category III; State Ambient values exist for particulates in non-designated classification areas as absolute values. Presently (January 1977), the oil shale area is designated as Class II under PSD regulations and as Category 1 under State Ambient Air Quality Standards.

The air quality sampling network utilized to obtain the background ambient levels is described in Sub-section 2.5.1. Comparisons of measured background levels with ambient standards are presented in Sub-section 3.2.4 along with recent EPA policy-related interpretations of the standards.

Table 2-7 AIR QUALITY STANDARDS

NATIONAL AMBIENT AIR QUALITY STANDARDS (NAAQS)

Emission	Averaging Time	Primary Standards (Human Health) (μg/m^3)	Secondary Standards (Public Welfare) (μg/m^3)
Sulfur Oxides (SO_2)	Annual	80	None
	24-hour*	365	None
	3-hour*	None	1300
Nitrogen Dioxide (NO_2)	Annual	100	100
Particulates	Annual†	75	60
	24-hour*	260	150
Hydrocarbons (corrected for CH_4)	3-hour* (6 to 9 a.m.)	160	160
Carbon Monoxide	8-hour*	10,000	10,000
	1-hour*	40,000	40,000
Oxidant (corrected for NO_2, SO_2)	1-hour*	160	160

* Not to be exceeded more than once per year.

† Geometric mean of the 24-hour concentrations.

MAXIMUM ALLOWABLE FEDERAL INCREMENTS FOR AREA CLASSES:
PREVENTION OF SIGNIFICANT DETERIORATION REGULATIONS (PSD)

Emission	Averaging Time	Class I (μg/m^3)	Class II (μg/m^3)	Class III (μg/m^3)
Particulates	Annual*	5	10	Same as NAAQS
	24-hour max	10	30	
Sulfur Dioxide	Annual†	2	15	
	24-hour max	5	100	
	3-hour max	25	700	

* Geometric mean of the 24-hour concentrations.

† Arithmetic mean of the 24-hour concentrations.

STATE OF COLORADO AMBIENT AIR QUALITY STANDARDS

Emission	Averaging Time	Maximum Allowable Increments over Baseline (μg/m^3) Category I	Category II	Max Allowable Concentrations (μg/m^3) Category III
SO_2	Annual	3	15	60
	24-hour max	15	100	260*
	3-hour max	75	700	1300*
	Maximum allowable ambient air concentrations in non-designated areas			
Particulates	Annual†	45		
	24-hour max*	150		

* Not to be exceeded more than once in a 12-month period.

† Arithmetic mean of the 24-hour concentrations.

2.4 Noise Standards

Noise pollution control standards are summarized on Table 2-8 along with identification of the controlling agency. The hearing of industrial workers is protected under regulations of both the U. S. Mine Enforcement Safety Administration (MESA) and the Occupational Safety and Health Administration (OSHA). Regulations pertain not only to noise intensity level, but to noise exposure, i.e., the product of intensity and time sometimes called "dose." Future noise control and hearing conservation programs will be conducted in this regard, as required. These measurements will be made on the surface and in the mine as required by regulations pertaining to occupational noise exposure. The concerns of this volume relate more to environmental monitoring of surface noise levels. Colorado revised statutes (1973), Title 25, Article 12 are the most specific in this regard and are summarized on Table 2-9. Definitions necessary for interpretation of this statute as applied to C-b are as follows:

db(A) means sound levels in decibels measured on the "A" scale of a standard sound level meter having characteristics defined by the American National Standards Institute, Publication S1.4 - 1971, and approved by the industrial commission of Colorado.

Decibel is a unit used to express the magnitude of a change in sound level. The difference in decibels between two sound pressure levels is twenty times the common logarithm of their ratio. In sound pressure measurements, sound levels are defined as twenty times the common logarithm of the ratio of that sound pressure level to a reference level of 2×10^{-5} N/m^2 (Newton's/meter squared). As an example, a three-decibel change is a 1000 percent increase or decrease in the sound level.

Industrial zone means an area in which noise restrictions on industry are necessary to protect the value of adjacent properties for other economic activity but shall not include agricultural operations.

This report is concerned mainly with Item 9 of Table 2-9, that of measurement of the ambient or background noise levels. Consideration has been and will continually be given to compliance with the maximum permissible noise levels for an industrial zone as specified in this table.

Table 2-8 NOISE POLLUTION CONTROL STANDARDS

Government Agency	Applicable Noise Pollution Standard
Federal	
Environmental Protection Agency (EPA)	40 CFR Part 202 - Motor Carriers Engaged in Interstate Commerce Effective October 15, 1975
	40 CFR Part 204 - Construction Equipment
	40 CFR Part 205 - Transportation Equipment Noise Emission Controls
U. S. Mine Enforcement Safety Administration (MESA)	30 CFR Part 57 - Health and Safety Standards, Metal and Non-metallic Underground mines
Occupational Safety and Health Administration (OSHA)	29 CFR Part 1910 - Occupational Safety and Health Standards
OSHA	29 CFR Part 1926 - Occupational Safety and Health Regulations for Construction
State	
Colorado	Colorado Revised Statutes, 1973, § 25 - 12 - 101 to § 25 - 108

Table 2-9

MAXIMUM PERMISSIBLE NOISE LEVELS UNDER COLORADO REVISED STATUTES (1973), TITLE 25, ARTICLE 12, NOISE ABATEMENT

25-12-103. Maximum permissible noise levels. (1) Every activity to which this article is applicable shall be conducted in a manner so that any noise produced is not objectionable due to intermittence, beat frequency, or shrillness. Sound levels of noise radiating from a property line at a distance of twenty-five feet or more therefrom in excess of the db(A) established for the following time periods and zones shall constitute prima facie evidence that such noise is a public nuisance:

Zone	7:00 a.m. to next 7:00 p.m.	7:00 p.m. to next 7:00 a.m.
Residential	55 db(A)	50 db(A)
Commercial	60 db(A)	55 db(A)
Light industrial	70 db(A)	65 db(A)
Industrial	80 db(A)	75 db(A)

(2) In the hours between 7:00 a.m. and the next 7:00 p.m., the noise levels permitted in subsection (1) of this section may be increased by ten db(A) for a period of not to exceed fifteen minutes in any one-hour period.

(3) Periodic, impulsive, or shrill noises shall be considered a public nuisance when such noises are at a sound level of five db(A) less than those listed in subsection (1) of this section.

(4) This article is not intended to apply to the operation of aircraft or to other activities which are subject to federal law with respect to noise control.

(5) Construction projects shall be subject to the maximum permissible noise levels specified for industrial zones for the period within which construction is to be completed pursuant to any applicable construction permit issued by proper authority or, if no time limitation is imposed, for a reasonable period of time for completion of project.

(6) All railroad rights-of-way shall be considered as industrial zones for the purposes of this article, and the operation of trains shall be subject to the maximum permissible noise levels specified for such zone.

(7) This article is not applicable to the use of property for purposes of conducting speed or endurance events involving motor or other vehicles, but such exception is effective only during the specific period of time within which such use of the property is authorized by the political subdivision or governmental agency having lawful jurisdiction to authorize such use.

(8) For the purposes of this article, measurements with sound level meters shall be made when the wind velocity at the time and place of such measurement is not more than five miles per hour.

(9) In all sound level measurements, consideration shall be given to the effect of the ambient noise level created by the encompassing noise of the environment from all sources at the time and place of such sound level measurement.

2.5 Sampling Network

2.5.1 Air Quality and Meteorology

The air-quality-meteorology monitoring network is shown in Figure 2-2. It consists of: 1) five air-quality stations (housed in trailers) for determining ambient levels of gaseous and particulate constituents and reporting the supporting meteorological data; 2) three mechanical weather stations for measurement of surface winds and temperatures; 3) a 200-foot meteorological tower to determine low-altitude vertical profiles of wind, temperature, and relative humidity; 4) two acoustic sounders for measuring atmospheric inversions; and 5) one location for measuring area-wide visibility. In addition, although not shown on Figure 2-2, upper air studies utilizing aircraft, free-flying balloons (pibals), and tethered balloons (tethersondes) have been conducted. The operational span for all network elements during the environmental baseline period is shown on Figure 2-3.

The five air quality stations locations are as follows:

Station No.	Description
020	Downwind of the proposed plant site in Piceance Creek valley at the Redd Ranch (off-Tract) (T2S, R97W)
021	In Piceance Creek valley at Rock School, downstream and generally downwind of Station 020 (off-Tract) (T2S, R97W)
022	In Piceance Creek valley at the Gerald Oldland Ranch, upstream and generally upwind of Station 020 (off-Tract) (T3S, R96W)
023	On the Tract near the proposed plant site which is the present location of a 200-foot meteorological tower (T3S, R96W)
024	On the Tract near the preliminary predicted point of estimated maximum concentrations downwind of the proposed plant site (T3S, R96W)

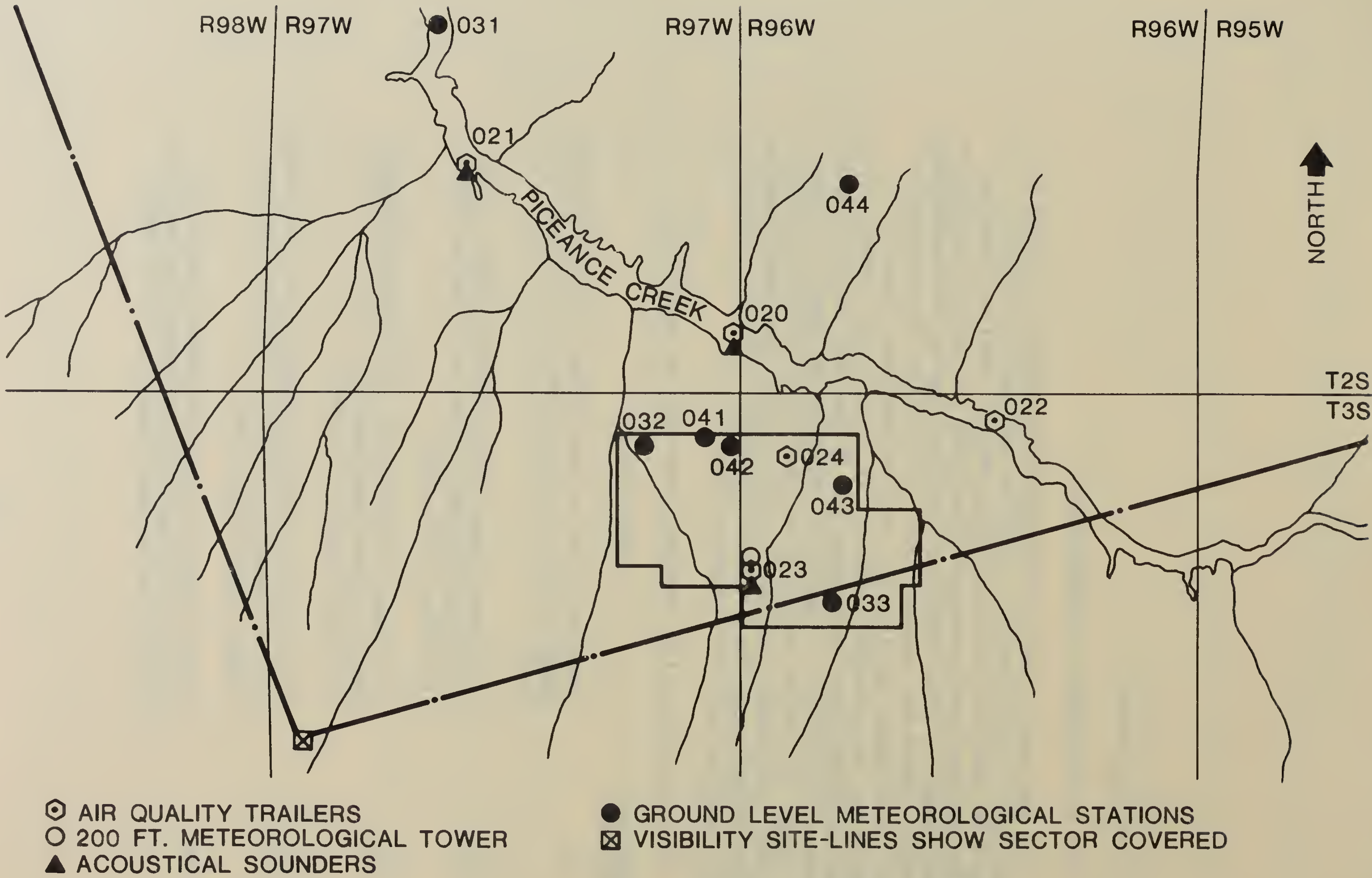


FIGURE 2-2 AIR QUALITY AND METEOROLOGICAL MONITORING NETWORK

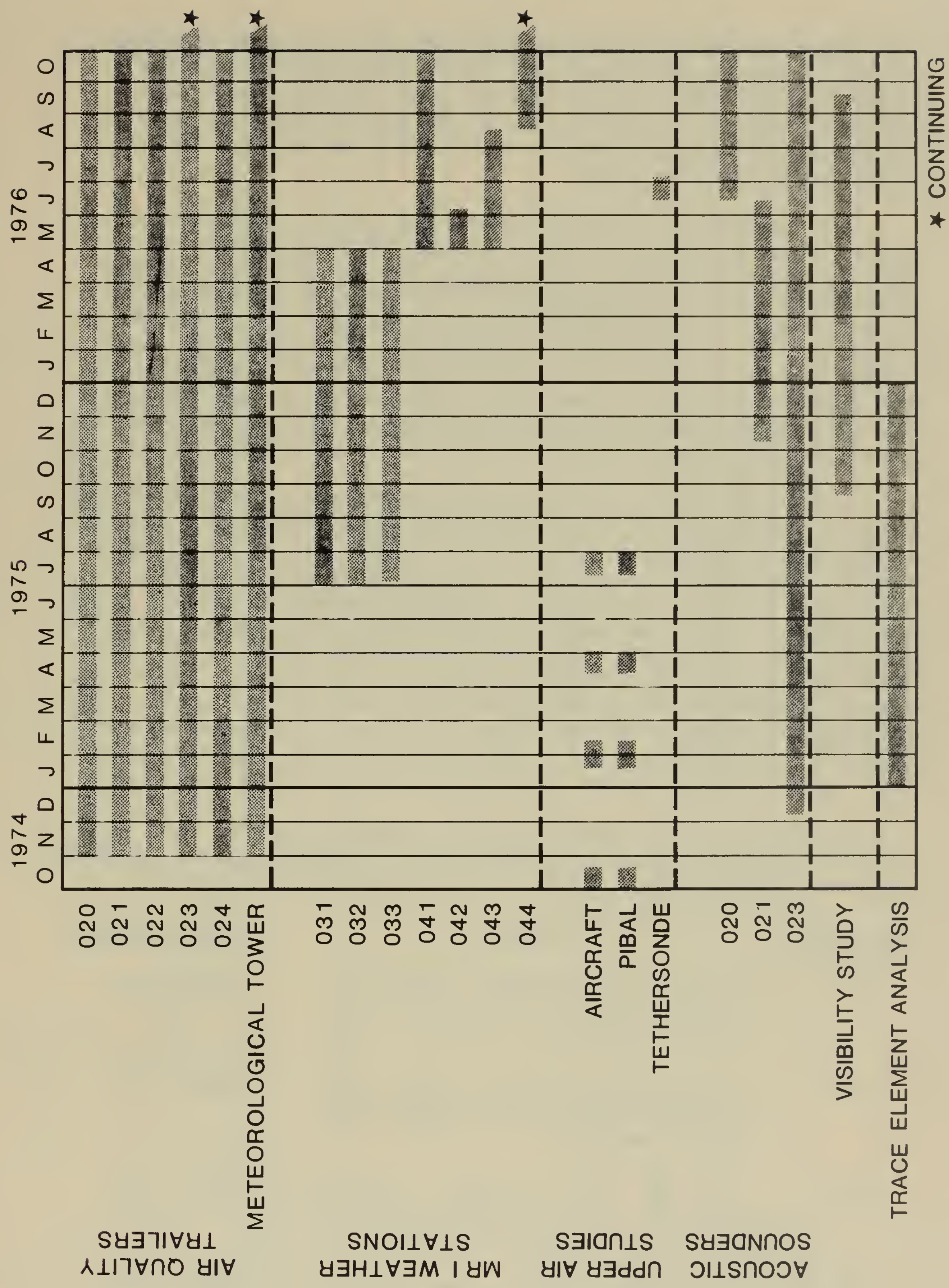


FIGURE 2-3 AIR QUALITY AND METEOROLOGY BASELINE NETWORK OPERATIONAL SPAN

The prevailing winds from the south and southwest were used to help determine the location of Station 024 downwind of the proposed plant site. The location of the predicted point of estimated maximum concentrations is not precise since it depends on assumed plant stack characteristics and preliminary wind and atmospheric stability data.

The topography of the Piceance Creek valley usually constrains the air mass within the valley resulting in the formation of upslope (or upstream) flow of air during the day and downslope (or downstream) flow of air at night. This upstream and downstream flow is monitored by Stations 020, 021, and 022. Turbulence, caused by the roughness of the topography, wind shear, and hydrostatic instability, is also a significant feature of the wind but one which is difficult to measure. Meteorological data taken at the five trailers and three weather stations create a better understanding of the complex wind patterns near the surface.

A detailed description of the air-quality and meteorology program, including the parameters measured and sampling frequencies, is presented in Tables 2-10 and 2-11. Sulfur dioxide, hydrogen sulfide, and suspended particulates were monitored at all air-quality stations. In addition, total hydrocarbons, methane, oxides of nitrogen, ozone, and carbon monoxide were monitored at Stations 020 and 023. Wind speed and direction were measured at a 30-foot level at each station. Relative humidity, temperature, and precipitation were also measured at each station; barometric pressure was measured at two stations and solar radiation at one station. In addition, three mechanical weather stations provided wind speed, wind direction, and temperature at hourly intervals.

Locations of the three mechanical weather stations have been changed during the baseline (Figure 2-2) to provide data at differing points of the complex flow field; these locations are:

Station No.	Location	Range/Township
031	Off-Tract in Piceance Creek near Dudley Bluffs in SW corner of NW 1/4 of Section 9	R97W, T2S
032	On northwest corner of Tract near Scandard Gulch in NE corner of SE 1/4 of Section 2	R97W, T3S
033	Near the southern edge of the Tract near West Fork of Stewart Gulch in NW corner of SW 1/4 of Section 17	R96W, T3S
041	On-Tract near the northern boundary in the NW corner of SE 1/4 of Section 1	R97W, T3S

Table 2-10 AIR QUALITY & METEOROLOGY DATA DESCRIPTION
Symbols represent sampling frequency on next table

Category & Location / Measurement	SO_2	H_2S	Particulates	Total Hydrocarbons	Methane (CH_4)	Non-CH_4 H.C. (1)	Ozone	NO_x	NO	NO_2 (2)	CO	Horizontal Wind Speed	Horizontal (3) Wind Direction	Bivane Wind Speed	Bivane Horizontal (3) Wind Direction	Bivane Vertical (3) Wind Direction	Relative Humidity	Air Temperature	Precipitation	Barometric Pressure	Solar Radiation	Temperature Difference	Inversion Top	Visible Range
Air Quality & Surface Meteorology																								
Trailer 020	X	X	O	Y	Y	Y	X	X	X	X	Y	X	X				X	X	X				&	
021	X	X	O									X	X				X	X	X				&	
022	X	X	O									X	X				X	X	X					
023	X	X	O	Y	Y	Y	X	X	X	X	Y	X	X				X	X	X	X	X		&	
024	X	X	O									X	X				X	X	X	X				
Mechanical Weather Station																								
031												Z	Z					Z						
032												Z	Z					Z						
033												Z	Z					Z						
041												Z	Z					Z						
042												Z	Z					Z						
043												Z	Z					Z						
044												Z	Z					Z						
Low Altitude Meteorology																								
@ Met. Tower																								
8-Ft.												X	X				X	X						
30-Ft.												X	X	X	X	X	X	X				1,2		
100-Ft.												X	X	X	X	X	X	X				1		
200-Ft.												X	X	X	X	X	X	X				2		
Upper Air Studies																								
A/C, Balloons												*,3	*,3				3	*,3						
Acoustic Sounder																								
@Trailer 020																							&	
@Trailer 021																							&	
@Trailer 023																							&	
Visibility																								
@ Hunter Creek																								#

(1) Obtained by Subtraction: THC-CH_4

(2) Obtained by Subtraction: NO_x-NO

(3) Std. deviation is calculated here also (Horizontal Wind Direction)

(3) Std. deviation is calculated here also (Bivane Horizontal Wind Direction)

(3) Std. deviation is calculated here also (Bivane Vertical Wind Direction)

Table 2-11 AIR QUALITY AND METEOROLOGY SAMPLING FREQUENCY AND MIN. AVERAGING TIMES

Symbols appear on previous table

Symbol	Sampling Frequency	Min. Average Time Or Report Frequency	Description
X	1/sec	5 min. average	AQ & low alt. met.
Y	5 min. average	5 min. average	
Z	Continuous	Hourly average	
O(1)	1/24 hr. span	(1) Daily Every 6th day Quarterly Quarterly Quarterly	(1) Particulates Trace elem. composites Gross radioactivity Part.size distribution Volatile Metals
1	1/sec	5 min. average	Temp. difference between 30' and 100' height on met. tower
2	1/sec	5 min. average	Temp. difference between 30' and 200' height on met. tower
*	at least 2 flights/day for 15 days/ quarter - Instantaneous Sample	100-foot interval for temp; 30 sec. interval for wind	High alt. meteorology profiles - temp. (via aircraft) and wind (via pibals) to 6000 ft. at Station 023
3	at least 1 flight/day @ Sta. 023 and 2/day @ Sta. 020 for 1-10 day test - instantaneous sample		Temp. and wind profiles to 2200 ft. (via tethersonde)
&	1/(14-sec)	Onset & Extent of Inversions	Acoustic echo (for Temp. Inversions & unstable layers)
#	7 times per day every 6th day	same as sampling	Area-wide visibility via photographic photometry

(1) Particulate samples of 24-hour duration are obtained from Hi-Vol samples utilizing fiberglass filters. Every sixth day a 24-hour particulate sample on a cellulose filter is obtained. The quarterly composites of these filters are screened for trace elements and radioactivity. In addition, volatile trace metals are collected and analyzed by special techniques.

Station No.	Location	Range/Township
042	On-Tract near the northern boundary near Cottonwood Gulch, NE corner of SE 1/4 of Section 1	R97W, T3S
043	On the northeast corner of the Tract near Stewart Gulch, NW corner of the NE 1/4 of Section 8	R96W, T3S
044	Off-Tract at Collins Overlook north of Piceance Creek, East Central Portion of NW corner of Section 20	R96W, T2S

The complex, near-surface, wind patterns vary with elevation above the surface. To assess this vertical variation, a 200-foot meteorological tower has been installed at Station 023. As indicated in Table 2-10, low altitude meteorological data were obtained on the meteorological tower at four levels (at 8, 30, 100, and 200 feet). These data consisted of wind direction and speed, relative humidity and temperature. Temperature differences were obtained between the 100-foot and the 30-foot levels and between the 200-foot and the 30-foot levels to assist in determination of atmospheric stability. Bivane wind speed and horizontal and vertical components of direction were measured at the 30-foot, 100-foot, and 200-foot levels.

Upper air studies were conducted to obtain vertical profiles of wind and temperature up to approximately 6000 feet above the surface. Wind data were obtained from pilot balloon (pibal) releases near Station 023 and from tethersonde releases at Stations 023 and 020. Vertical temperature profiles were obtained by an instrumented aircraft flying in ascending and descending spirals and from the tethersonde. A knowledge of the variation in the temperature (T) with increasing altitude (z) (called the lapse rate) helps in determining atmospheric stability. If the actual lapse rate (dT/dz) is less negative than the dry adiabatic lapse rate (DALR), then the atmosphere is said to be stable and the vertical diffusion of gaseous constituents is inhibited. If the actual lapse rate is more negative than the DALR, then the atmosphere is said to be unstable and the diffusion proceeds freely in both the horizontal and vertical directions. When the atmospheric air temperature increases with height, an inversion is said to be present.

Two acoustic sounders have been installed both on the Tract (at Station 023) and in Piceance Creek valley (at Station 021 later moved to Station 020). These sounders measured inversion heights continuously by emitting an audio pulse every 14 seconds and measuring the time for a return echo. If turbulence exists in layers of either stable or unstable air, sound energy is scattered by the layers. The time of pulse travel is directly

proportional to height to the top of the scattering layer. The specific "signature" (recorded pattern) indicates stability or instability.

A joint visibility study with the Rio Blanco Oil Shale Project (Tract C-a) was started in September 1975. The visual-range in miles was measured every sixth day during a one-year period at the Hunter Creek ridge site, a point about midway between Tracts C-a and C-b (See Figure 2-2). Each measurement included photographs of designated objects in each of four viewing directions covering an approximate 90^0 north-to-east sector. Each view was photographed at specified times during the day with both black and white and color film. The contrast between the object image and the background sky, as determined from the film negative, was used to compute the visual-range in miles.

As was previously mentioned, Tables 2-10 and 2-11 give an overview of the data description and associated sampling frequencies. Tables 2-12 to 2-20 identify each type of basic data set and associated minimum sampling time interval.

2.5.2 Noise

The environmental baseline noise network is shown on Figure 2-4; stations are located approximately as follows:

Station No.	Section/Township/Range	Location
I	32/T2S/R96W	Off-Tract at the junction of Collins Gulch Road and Piceance Creek Road
II	25/T2S/R97W	Off-Tract on Piceance Creek Road, 3/8 mi. east of the P-L Ranch turnoff
III	13/T3S/R97W	On-Tract at the corehole SG-10 drill pad near proposed plant site
IV	7/T3S/R96W	On-Tract near corehole SG-11
V	11/T3S/R97W	On-Tract, ridge between Little Scandard Gulch and Willow Creek near SG-9
VI	6/T3S/R96W	On-Tract, near northern boundary, corehole C-b2

Table 2-12 TRAILER DATA ENTRIES FOR BASIC 5- MIN. DATA SET

	020	021	022	023	024
1.	NO_x	SO_2	SO_2	NO_x	SO_2
2.	NO	WS	WS	NO	WS
3.	SO_2	WD	WD	SO_2	WD
4.	WS	RH	RH	WS	RH
5.	WD	TIN	TIN	WD	TIN
6.	RH	TOUT	TOUT	RH	TOUT
7.	TIN	H_2S	H_2S	TIN	H_2S
8.	TOUT	O_3	O_3	TOUT	O_3
9.	H_2S	WSD	WSD	PYR	WSD
10.	THC	RAIN	RAIN	H_2S	RAIN
11.	CH_4			THC	
12.	CO			CH_4	
13.	O_3			CO	
14.	WSD			O_3	
15.	RAIN			PRES	
16.				RAIN	

Table 2-13 MET. TOWER DATA ENTRIES
FOR BASIC 5-MIN. DATA SET

1. WSI (8-foot)
2. WDI (8-foot)
3. RHI (8-foot)
4. TMPI (8-foot)
5. WS2 (30-foot)
6. WD2 (30-foot)
7. RH2 (30-foot)
8. TMP2 (30-foot)
9. WS3 (100-foot)
10. WD3 (100-foot)
11. RH3 (100-foot)
12. TMP3 (100-foot)
13. WS4 (200-foot)
14. WD4 (200-foot)
15. RH4 (200-foot)
16. TMP4 (200-foot)
17. DT1 (30-100 ft)
18. DT2 (30-200 ft)
19. BWS1 (30-foot)
20. HWD1 (30-foot)
21. VWD1 (30-foot)
22. BWS2 (100-foot)
23. HWD2 (100-foot)
24. VWD2 (100-foot)
25. BWS3 (200-foot)
26. HWD3 (200-foot)
27. VWD3 (200-foot)
28. WSD1
29. WSD2
30. WSD3
31. WSD4
32. HSD1
33. VSD1
34. HSD2
35. VSD2
36. HSD3
37. VSD3

Table 2-14 NOMENCLATURE FOR THE VARIOUS AIR QUALITY AND METEOROLOGICAL TOWER CHANNELS

BWS1	Wind speed at 30 feet (Bivane)
BWS2	Wind speed at 100 feet (Bivane)
BWS3	Wind speed at 200 feet (Bivane)
CH_4	Methane in parts per billion
CO	Carbon Monoxide in parts per billion
DT1	Temperature between 100 feet and 30 feet (T_{100}-T_{30}) A (-) precedes negative values in hundredths of degrees Fahrenheit.
DT2	Temperature between 200 feet and 30 feet (T_{200}-T_{30}) (hundredths of degrees Fahrenheit)
H_2S	Hydrogen Sulfide in parts per billion
HSD1	Standard deviation of horizontal wind direction at 30 feet (Bivane)
HSD2	Standard deviation of horizontal wind direction at 100 feet (Bivane)
HSD3	Standard deviation of horizontal wind direction at 200 feet (Bivane)
HWD1	Horizontal wind direction at 30 feet (Bivane)
HWD2	Horizontal wind direction at 100 feet (Bivane)
HWD3	Horizontal wind direction at 200 feet (Bivane)
NO	NO in parts per billion
NO_X	NO_X in parts per billion
O_3	Ozone in parts per billion
PRES	Station pressure in millibars
PYR	Pyranometer readings in cal/cm^2/min
RAIN	Precipitation rates in .01 inches. "1" bucket tip or pulse represents .01 inch of precipitation, in a rate-of-fall representation.
RH	Relative humidity, trailer
RH1	Relative humidity at 8 feet, expressed as a percentage
RH2	Relative humidity at 30 feet, tower
RH3	Relative humidity at 100 feet

Table 2-14 (Cont'd)

RH4	Relative humidity at 200 feet
SO_2	SO_2 in parts per billion
THC	Total Hydrocarbons in parts per billion
TIME	Mountain Standard Time
TIN	Inside (trailer) temperature in ^{o}F
TMP1	Temperature at 8 feet, in ^{o}F
TMP2	Temperature at 30 feet in ^{o}F
TMP3	Temperature at 100 feet
TMP4	Temperature at 200 feet
TOUT	Outside (trailer) temperature at 30 feet in ^{o}F
VSD1	Vertical wind direction standard deviation at 30 feet (Bivane)
VSD2	Vertical wind direction standard deviation at 100 feet (Bivane)
VSD3	Vertical wind direction standard deviation at 200 feet (Bivane)
VWD1	Vertical wind direction at 30 feet (Bivane)
VWD2	Vertical wind direction at 100 feet (Bivane)
VWD3	Vertical wind direction at 200 feet (Bivane)
WD	Wind direction at 30 feet in ^{o} , trailer
WD1	Wind direction at 8 feet in degrees , referenced clockwise from true north
WD2	Wind direction at 30 feet in degrees , tower
WD3	Wind direction at 100 feet
WD4	Wind direction at 200 feet
WS	Wind speed at 30 feet in miles per hour, trailer
WS1	Wind speed at 8 foot level in miles per hour
WS2	Wind speed at 30 feet in miles per hour, tower
WS3	Wind speed at 100 feet in miles per hour
WS4	Wind speed at 200 feet

Table 2-14 (Cont'd)

WSD	Standard deviation of horizontal wind direction at 30 feet, trailer
WSD1	Standard deviation of horizontal wind direction at 8 feet
WSD2	Standard deviation of horizontal wind direction at 30 feet, tower
WSD3	Standard deviation of horizontal wind direction at 100 feet
WSD4	Standard deviation of horizontal wind direction at 200 feet

Table 2-15 AIRCRAFT DATA SET ENTRIES

Item	Units
Date	
Flight Number	
Mountain Standard Time at Start	hr; min; sec
Altitude (altimeter reading)	ft
Air Temperature	^{o}C

NOTE: Basic data sets were obtained in 100-foot altitude increments, except for the "quick-look" days (January 28-29, 1975 and April 28-29, 1975) for which the increments were 50-foot.

Table 2-16 PIBAL DATA ENTRIES FOR
BASIC 30-SEC. DATA SET

Item	Units
Date	mo/da/yr
Flight Number	--
Mountain Standard Time	hr:min:sec
Time into Flight	min:sec
Azimuth	deg.
Elevation	deg.
Height (above surface)	ft.
Horizontal distance north (+) or south (-) of launch (x)	ft.
Horizontal distance east (+) or west (-) of launch (y)	ft.
Interpolated (average) height	ft.
Interpolated (average) wind speed	mph
Interpolated (average) wind direction	deg.

Table 2-17 TETHERSONDE DATA ENTRIES FOR EACH 1-MIN DATA SET

Symbol	Meaning	Units
F	Flight Number	--
S	Site Number	--
Y	Year	yr
M	Month	mo
D	Day of month	day
P_o	Station pressure	millibars
TI	Mountain Standard Time	hr, min, .1 min
P	Pressure difference between surface and level H	mb
T	Air temperature	^oF
Tw	Wet bulb temperature	^oF
R	Relative humidity	%
V	Wind speed	mph
D1	Wind direction	deg. clock. from N
H	Height above surface	ft
Θ	Potential temp. referred to 1000 mb	^oK

Table 2-18 MRI MECHANICAL WEATHER STATION
DATA ENTRIES FOR BASIC 1-HOUR DATA SET

Item	Units
Date	mo/da/yr
Mountain Standard Time	hour
(Horizontal) Wind Speed	mph
Wind Direction	deg.
Air Temperature	^{o}F

NOTE: Basic data are obtained from continuous analog "strip charts," read as hourly averages.

Table 2-19 ACOUSTIC SOUNDER BASIC DATA SET

Item	Units
Date	mo/da/yr
Station	Site number (non-dim)
Time of Start of Inversion (MST)	Hours
Height of Top of Inversion (Repeated every 0.5 hr. until break-up)	ft

NOTE: These digital data are obtained from continuous analog signatures, manually interpreted as to the top of stable atmosphere layers.

Table 2-20 VISUAL RANGE DATA SET

Item	Units
Date	mo/da/yr
Time of Day (MST)	hr:min:sec
View (I through IV)	non-dim.
Visual Range*	mi

*As obtained from black-and-white photographic photometry utilizing a 35 mm camera attached to an 800 mm refractive lens.

NOTE: 1) One color photograph was also obtained to record general haziness in each view.

2) Measurements were taken every 6th day for a one-year period seven times per day.

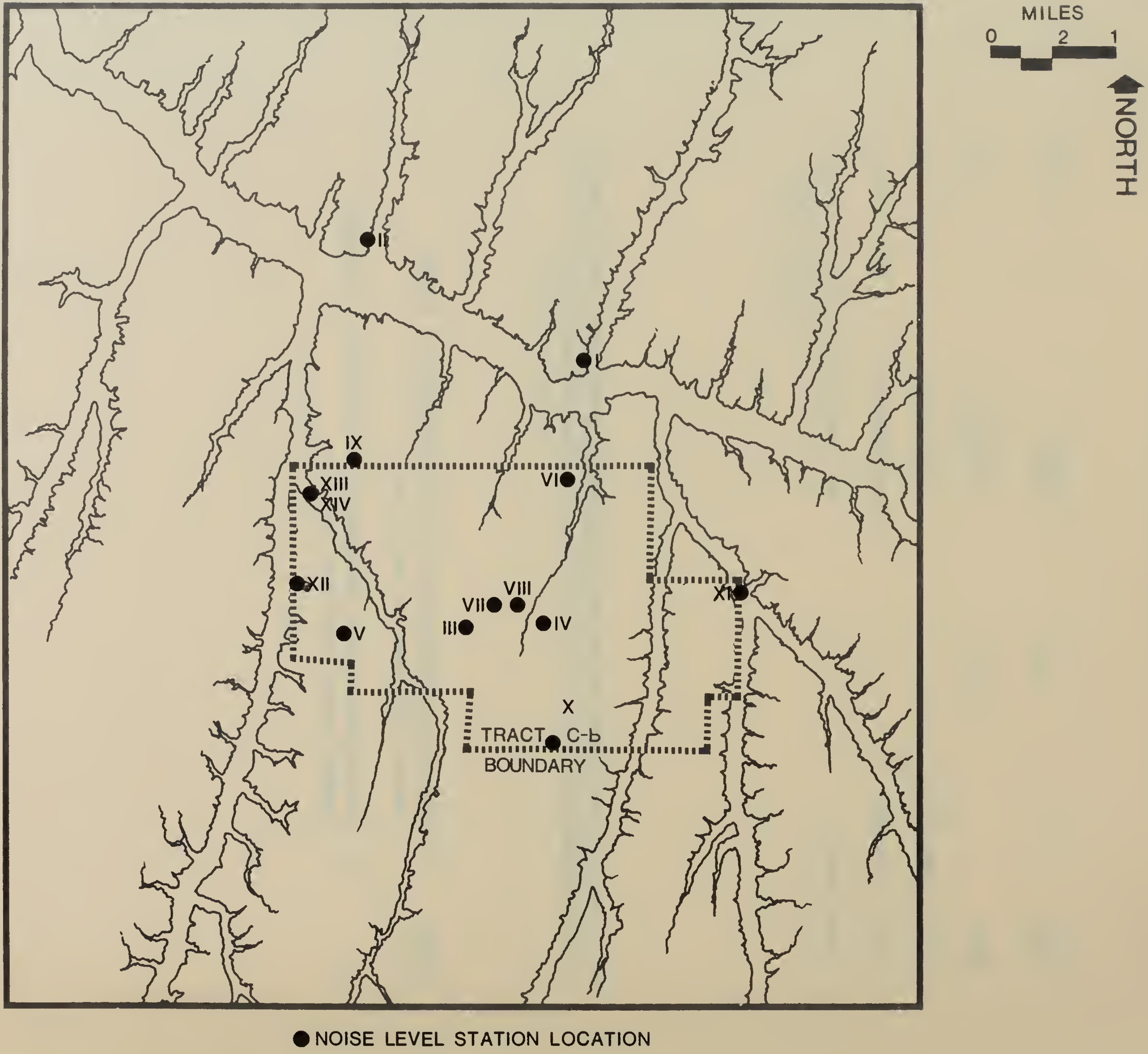


FIGURE 2-4 TRACT C-b ENVIRONMENTAL NOISE NETWORK

Station No.	Section/Township/Range	Location
VII	7/T3S/R96W	On-Tract at aquifer test site AT-1
VIII	7/T3S/R96W	On-Tract 1/4 mile east of AT-1
IX	1/T3S/R97W	On the northern Tract boundary line on the main access road
X	18/T3S/R96W	On the Tract southern boundary line, near SG-16
XI	9/T3S/R96W	On the Tract eastern boundary line near SG-8 and A-9
XII	11/T3S/R97W	On the Tract western boundary line on Willow Creek Road
XIII	2/T3S/R97W	On-Tract in the valley bottom near SG-1
XIV	2/T3S/R97W	On-Tract on the ridge near SG-1

This program has documented baseline levels of noise on Tract C-b and along the roads leading to the Tract. Actual noise level measurements complement traffic noise predictions made from Colorado State Highway statistics.

A general Radio 1565-B Sound-Level Meter was used to record the noise level at each of the above sites; the peak measurement reading on the A-, B-, and C-weighting scales was recorded. Measurements were made for a one-minute duration at each station on one day per month for 13 months.

Colorado State Highway 1974 data have been used with a correlation curve to estimate traffic noise levels in the Piceance Creek basin and surrounding areas as shown in Table 2-21 for the 13 traffic sampling stations shown on Figure 2-5.

Table 2-21

APPROXIMATE TRAFFIC NOISE LEVELS AT LOCATIONS IN

PICEANCE CREEK BASIN AND SURROUNDING AREAS[1]

(During peak hour of traffic, average 24-hour day, 1974)

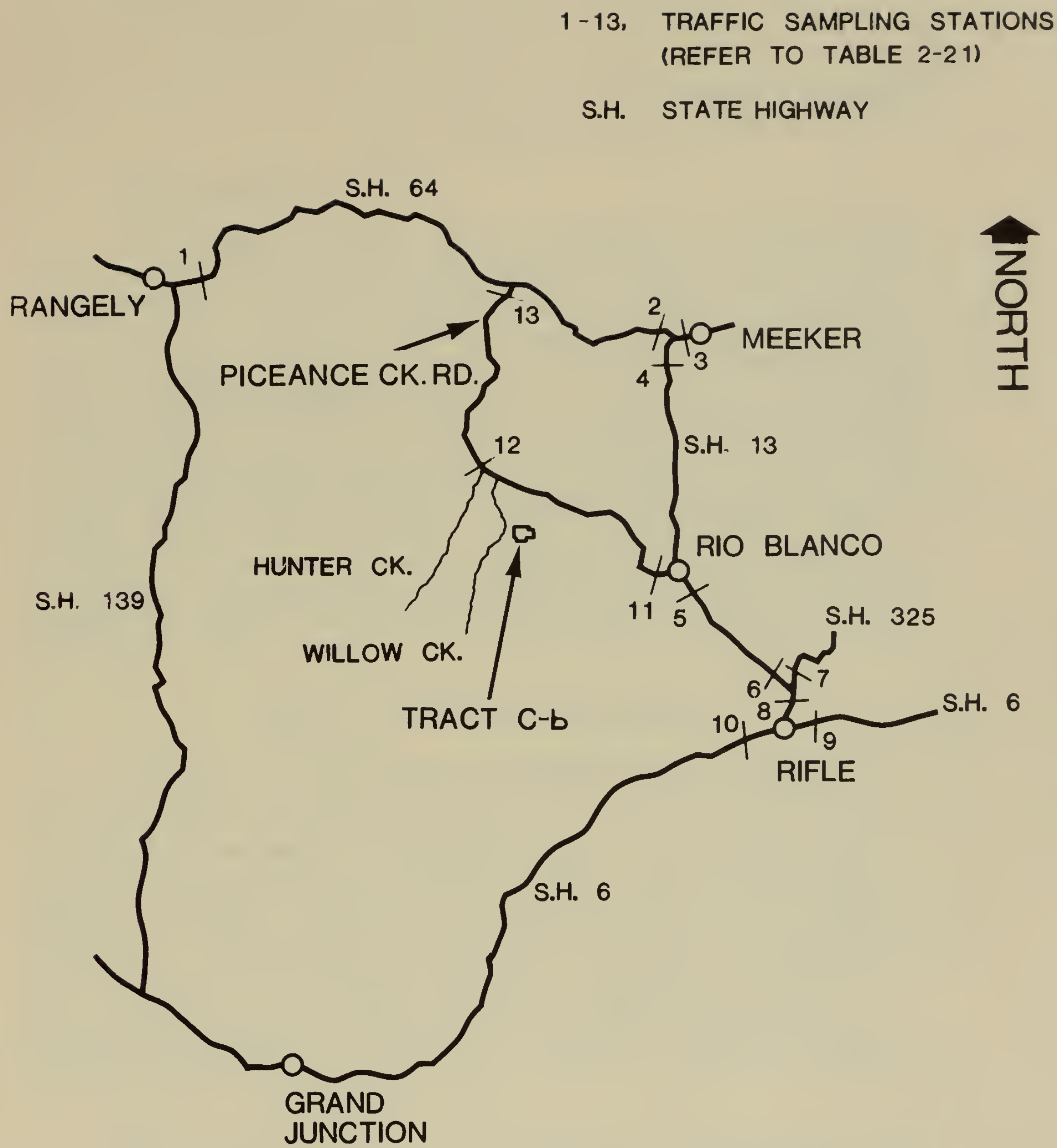
Location Number	Location Description[2]	Noise Level[3] L_{10} dBA
1	S.H.[4] 64 east of Junction S.H. 64 & S.H. 139	62
2	S.H. 64 west of Junction S.H. 64 & S.H. 13	60
3	S.H. 64 east of Junction S.H. 64 & S.H. 13	59
4	S.H. 13 south of Junction S.H. 13 & S.H. 64	61
5	S.H. 13 at Junction S.H. 13 & Piceance Creek Road	61
6	S.H. 13 north of Junction S.H. 13 & S.H. 325	63
7	S.H. 325 east of Junction S.H. 13 & S.H. 325	58
8	S.H. 13 south of Junction S.H. 13 & S.H. 325	61
9	S.H. 6 east of Junction S.H. 6 and S.H. 13	66
10	S.H. 6 west of Junction S.H. 6 and S.H. 13	66
11	Piceance Creek Road west of Junction Piceance Creek Road & S.H. 13	53
12	Junction Piceance Creek Road and Local Road approximately 17.6 miles west of Junction Piceance Creek Road & S.H. 13	53
13	Piceance Creek Road wouth of Junction Piceance Creek Road and S.H. 64	53

(1) Noise levels predicted by utilizing 1974 Colorado State Highway Statistics, "Nomograph For Approximate Prediction of Highway Noise Levels," and data from Colorado State Highway Department Computer Program DFINCLS.

(2) Locations shown in Figure 2-5.

(3) Noise level at location 500 feet from highway.
L_{10} - the sound level that is exceeded 10 percent of the time for the time period under consideration (1 hour).
dBA - Noise level in decibels on "A" weighting scale, a weighting technique to approximate the response of the human ear to noise of various frequencies.

(4) S.H. - State Highway.



STATE HIGHWAY TRAFFIC SAMPLING STATIONS

FIGURE 2-5 PICEANCE BASIN 1974

3.1 Meteorology

In Section 2.1.1 the lease requirements and stipulations for air quality and meteorology were discussed; the baseline meteorology program has been designed to comply with both. In Section 2.5.1 the air quality and meteorology sampling network was detailed. In this section wind fields, temperature fields, and other meteorological parameters (solar radiation, relative humidity, and barometric pressure) are presented. In general wind fields are driven primarily by differential heating of the area topography and as such are local, diurnally variable, and complex and therefore require a detailed examination. The reader should consult Appendix A for a detailed presentation of both methodology and quality assurance for all meteorological programs. A resume of the continuous meteorological trailer, tower, and mechanical weather station instrumentation is as follows:

Ambient Air Monitoring Trailers

All five of the ambient air monitoring trailers are equipped with the following meteorological instrumentation: (1) dry bulb temperature (outside), (2) relative humidity, (3) wind direction, (4) wind speed, and (5) a tipping bucket, heated rain/snow gauge. The temperature probe and relative humidity sensor are mounted inside a motor-aspirated radiation shield, the Model 1S6, by Weather Measure, which gives an aspiration of approximately 100 cfm. The wind instrumentation and temperature and relative humidity apparatus (in the aspirated radiation shield) are all mounted atop a 33-foot crank-up meteorological tower (the WM-33, by Weather Measure) at each of the five trailer sites.

The wind instrumentation at the monitoring trailers consists of the Model W103/3L lightweight cup anemometer by Weather Measure and the Model W104-2 lightweight vane by Weather Measure, the latter equipped with a low torque potentiometer and two wipers for 0^0 to 540^0 operations. The thermistor probe used in the motor aspirated radiation shields is the Model T621-TP18X air temperature premium thermistor probe by Weather Measure. The relative humidity sensor is the Model

2013 remote-reading relative humidity system by Texas Electronics. Each of the five monitoring trailers is equipped with a Model P511-E remote recording heated snow gauge by Weather Measure. In addition, the trailer at site 023 has an Epply precision spectral pyranometer and a Weather Measure analog output barometer.

200-Foot Meteorological Tower

The tower has instrumentation at four levels: 8 feet, 30 feet, 100 feet, and 200 feet. At all four levels there are: wind speed, wind direction, temperature and relative humidity sensors, the latter two in a power-aspirated radiation shield. Temperature-difference thermistors (also in power-aspirated radiation shields) and their associated circuitry take lapse-rate measurements for the 30-foot to 100-foot layer and the 30-foot to 200-foot layer.

Back-up instrumentation in the form of bivanes for measurement of wind speed and both components of wind direction is provided at the 30-foot, 100-foot, and 200-foot levels.

The wind direction and speed apparatus (other than bivanes) used at each measurement level of the tower is the Model 1074-2 wind sensor by Meteorology Research, Inc. (MRI). This sensor has a 540^0 potentiometer for wind direction and a light chopper for wind speed. Bivanes are the Gill anemometer bivane Model 21002 by RM Young, Inc. The relative humidity and temperature sensors are mounted within a power-aspirated radiation shield at each tower level. All aspirators and sensors are of the Model 840 Series by MRI. The temperature sensor is comprised of a dual thermistor and resistor network. This circuit provides a linear resistance change with an air temperature change. The relative humidity sensor is placed alongside the temperature elements inside the shield where it is exposed to a constant flow of air.

Measurements of temperature difference are taken for two layers, the 30-foot to 100-foot and the 30-foot to 200-foot layer. The thermistors and circuitry used for these measurements are separate from the thermistors measuring air temperature. The use of separate thermistors and circuitry to measure ΔT allows for much greater accuracy and resolution in the measurements, which is necessary for stability assessments. Two ΔT thermistors are located at the 30-foot level, one is at the 100-foot level, and one is at the 200-foot level. All of these ΔT thermistors are mounted within power-aspirated radiation shields.

The meteorological tower itself is a 200-foot Rohn Model 80 guyed tower, designed for 40 pounds per square foot wind load with ½" of radial ice per EIA Standard RS-222-B to support four levels of meteorological equipment. The material consists of

tower sections with a tapered base, three retractable instrument booms (at 30', 100', and 200' levels) 12 feet long, three outside work platforms, an inside ladder for climbing, two base ground kits, and one anchor ground kit. The cable-type safety climbing device consists of a cable and attachment mechanisms with a locking sleeve and safety belt. The tower is lighted and painted according to FAA specifications.

The three mechanical weather stations record temperature, wind speed, and wind direction. Each station is a Model 1071 by Meteorology Research, Inc.

3.1.1 Wind Fields

3.1.1.1 Rationale

The study of wind fields in the vicinity of the C-b Tract is important in that winds affect the transport and diffusion of air pollutants. It is the baseline meteorological data on wind persistence by atmospheric stability class that provide necessary inputs to air diffusion models which, in turn, are used to demonstrate compliance of the oil-shale plant with air quality standards. Wind-direction variability measurements provide one basic method for determination of atmospheric stability. Also, wind measurements are essential to provide environmental design criteria for structural design purposes (e.g. peak wind loads).

3.1.1.2 Objectives

The objectives of the wind field investigations were to (1) document the baseline wind fields in the rough-terrain area of the C-b Tract as hourly, daily, and monthly averages where appropriate, (2) provide data on wind persistence by atmospheric stability class, (3) determine station-to-station correlations which may exist, (4) provide supporting data to air quality analyses which are meteorologically dependent and (5) provide initial peak-wind information for design criteria.

3.1.1.3 Experimental Design

The meteorological network shown in Figure 2-2 obtained horizontal, continuous wind information from the five air quality trailer locations (at 30' local height) and three mechanical weather stations (at 7' local height) previously described in Section 2.5.1. Vertical distributions of horizontal wind velocity have been obtained from continuous measurements on the 200-foot meteorological tower which is instrumented at 8-, 30-,

100-, and 200 feet, and short-term studies utilizing both free-flying and tethered balloons (called pibals and tethersondes respectively). Pibals were released near Station 023 and tethersondes near Stations 023 and 020.

3.1.1.3.1 Measurement Frequency

Consult Table 2-11 for details. Trailer and tower data were sampled once per second; 300 of these samples were averaged to obtain one 5-minute average. Continuous trailer and tower data were obtained over the entire two-year baseline period.

Continuous wind speed and direction were obtained from the mechanical weather stations from analog strip charts; operational span of these stations is given on Figure 2-3. It is to be noted that the weather stations at Stations 031, 032, and 033 became operational in July 1975 and were moved to new locations in May 1976 to provide wind field data over a wider area and redesignated as Stations 041, 042, 043 at that time.

Pibal data were obtained from a single theodolite release as part of the upper air studies (along with temperature soundings by aircraft) on a quarterly basis starting in the fall 1974 and proceeding through the winter, spring, and summer of 1975. Flight successes were obtained 15 days per quarter with four flight attempts (0530, 0830, 1130, 1700 MST) per day. At least two successes per day were required, one of which was an early-morning flight.

For the 10-day tethersonde study (during late June and July 1976) two stations were selected for alternate flights made at two-hour intervals six times a day. The times for the flights were selected to show conditions during the stable, early morning hours, to provide night-to-day transition data, and to yield information about mid-day convective activity. A total of 59 flights were made. One data frame is produced per minute in this time-multiplexed system for which wind speed is sampled twice and pressure (used to obtain height from the hydrostatic equation) and wind direction are sampled once.

3.1.1.3.2 Data Reporting

Trailer and tower data were reported as 5-minute, hourly, daily, and monthly averages in monthly data reports. Tables 2-12, 2-13, and 2-14 present basic data sets. Over 50 percent of the 5-minute samples are required to compute an hourly average; otherwise that hour is recorded as blank. Additional data in the monthly reports included maximum 5-minute averages,

five maximum independent sliding averages, influence of wind direction on air quality parameters, diurnal variations, stability class, wind-rose diagrams, stability wind-rose diagrams, wind bivariate frequency distributions, and monthly meteorological summaries over North America, western Colorado, and the C-b Tract.

Mechanical weather station data were obtained as hourly averages, which, in turn, were averaged for daily and monthly values. Additional data reported in the quarterly reports included maximum hourly averages, diurnal variations, wind-rose diagrams, and wind bivariate-frequency-distributions.

Pibal data for the quarterly studies were obtained every 30 seconds; the basic data set is given on Table 2-16.

Tethersonde basic data for the ten-day study are presented in Table 2-17 for each one-minute data set. Derived data on wind-speed-and-direction standard deviations are discussed in Section A.4.

3.1.1.4 Methodology

Detailed tower and trailer instrumentation and data acquisition system description and instrumentation accuracy are included in the appendix in Section A.1, mechanical weather station in A.5. Data sampling and reporting frequency have been previously described. Reporting frequencies for meteorology were consistent with sampling intervals required for air quality monitoring.

The pibal study methodology is discussed in the appendix in Section A.2. It may be summarized as follows.

The vertical structure of the horizontal wind from the surface of the Tract (7000 feet MSL) to 13,000 feet MSL, or cloud base, was determined four times per day with 30-gram pilot balloons in conjunction with a theodolite. The theodolite was positioned at the SG-10 well site, 800 meters north-northwest of the main meteorological monitoring station. The theodolite was aligned to magnetic north and then corrected to true north by rotating it 15 degrees counterclockwise. The balloons were "weighed off" by using a standard National Weather Service inflation kit for 30-gram balloons inside an enclosed shelter to negate the influence of wind and then released. These balloons rise at an approximately constant rate of 600 feet per minute.

The balloons were released at approximately 0500, 0800, 1100, and 1700 hours MST in conjunction with temperature soundings. At 30-second intervals, azimuth and elevation were vocally

recorded to within 0.1 degree, although interpolations were attempted to within 0.02 degree. The balloons were kept in the field of view at all times. After the sounding was completed, the voice records were transcribed to data sheets.

Tethersonde methodology is discussed in the appendix in Section A.4. In summary, it is a low-level tethered balloon sounding system, consisting of a sensor subsystem, a telemetry subsystem, a recorder, an aerodynamically-shaped balloon to carry the sensor subsystem aloft, and a winch to control the balloon. The sensor subsystem contains sensors for barometric pressure, temperature, wet-bulb temperature, wind speed, and a magnetic compass. The compass was maintained in a fixed relationship with the balloon and the orientation of the balloon is taken as the wind direction.

The telemetry transmitter and some sensor conditioning circuitry were located in the airborne package on which the sensors are mounted. The package was suspended far enough below the balloon to be free of the balloon's influence.

The telemetry receiver and a discriminator were located in the ground station. The incoming signal was received by the receiver and changed from a frequency to a voltage by the discriminator. It was then sent to the recorder. The telemetry system was time-multiplexed.

The tethersonde may be used to make vertical soundings at a nearly uniform ascent or descent rate, or it may be flown at approximately a constant level to obtain data at that level. At the C-b Tract it was used in both of these modes.

The contribution of data from the five air quality trailers and three MRI stations was utilized to study horizontal flow patterns, associated interstation correlations, and analyses of wind-direction persistence by atmospheric stability class. The combination of meteorological tower, pibals and tethersonde was utilized to obtain vertical profiles of the wind and associated data on atmospheric stability by several alternative techniques. Data at Grand Junction provided a synoptic-type source of meteorological measurements.

3.1.1.5 Results and Discussion

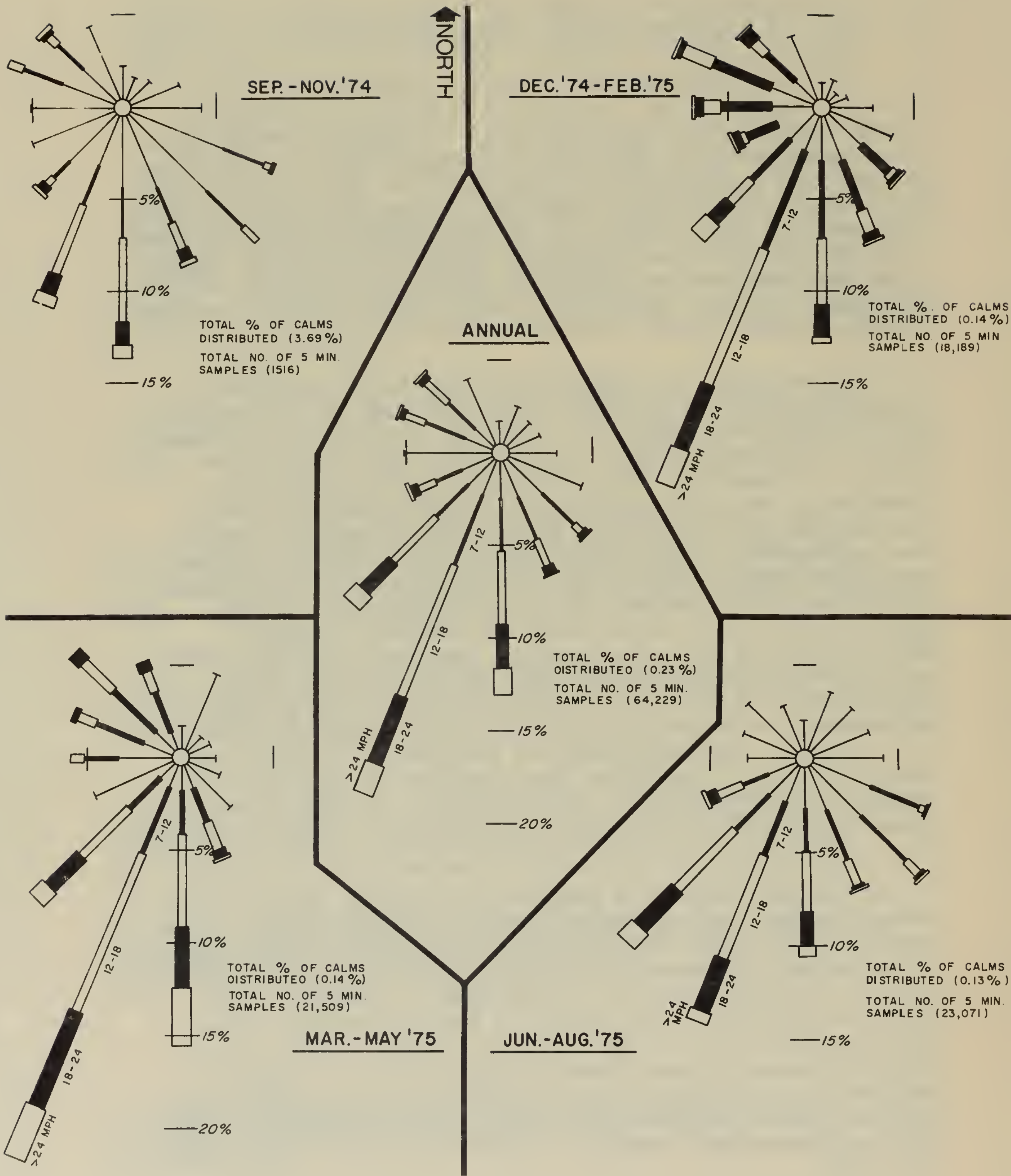
This discussion is presented in two parts: (a) near-surface wind fields and (b) vertical structure of the wind and its variations.

3.1.1.5.1 Near-Surface Wind Fields

The meteorological conditions that prevailed in the Tract C-b region during the baseline period were often quite diverse because of terrain influences. The meteorology of the three stations in the Piceance Creek valley (Stations 020, 021, and 022) was dominated by the effects of the two local circulation cells, the katabatic (downslope flow at night) and anabatic (upslope flow during the day). On the plateau the meteorological tower (Station 023) and Station 024 normally experienced conditions that were more macroscale in nature (e.g., wind directions and speeds that were induced by synoptic-scale pressure gradients and thermal fields that reflected large-scale patterns).

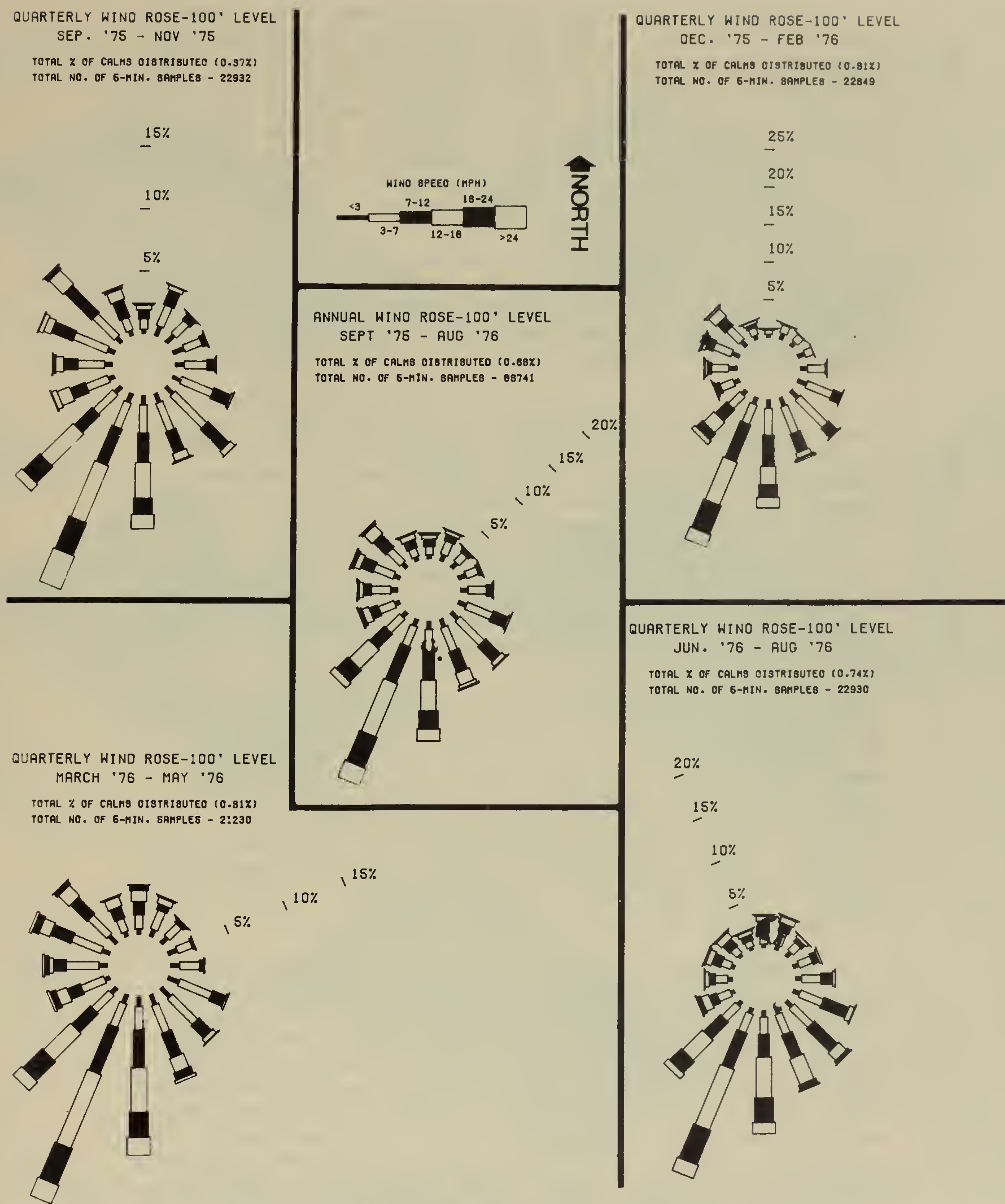
The walls of the Piceance Creek valley had a marked channeling effect on the wind. The wind-roses for the valley stations exhibited primarily a northwest-southwest flow couplet during the 24 month period. The southeasterly winds (down creek) were caused by the nighttime and morning katabatic circulation, while the northwesterly winds, induced by the anabatic circulation cell (up creek) were primarily an afternoon phenomenon. Channeling effects from the terrain concentrated the winds associated with these localized circulations. The katabatic cell was more strongly developed during the winter months, while the anabatic cell was more strongly developed during the summer months. However, since the anabatic cell never attained the persistence of the katabatic cell (approximately a ratio of 1 to 2 with regard to directional persistence) and since winds were generally light and variable on a synoptic scale during much of the summer, the wind roses for the Piceance Creek valley show more directional variability during the later spring and summer months. The effects of channeling and the local circulations are most marked at Station 022.

The wind-roses for the meteorological tower, where channeling and localized effects are not as significant, showed that the winds had a significant westerly component during most of the period. Figures 3-1a and 3-1b present wind-roses on an annual and quarterly basis for each year of baseline. This westerly influence exists because of synoptic-scale effects, since the basic flow of the long-wave pattern is west-to-east. South-southwesterly winds were most common at this location indicating the influence of the katabatic flow at tower levels. Because of its elevation and exposure, the meteorological tower also experienced much stronger winds than did the other monitoring sites.



METEOROLOGICAL TOWER 100' ELEVATION
QUARTERLY AND ANNUAL WIND ROSES
a. 1974-1975

FIGURE 3-1a



METEOROLOGICAL TOWER 100′ ELEVATION
QUARTERLY AND ANNUAL WIND ROSES
b. 1975-1976

FIGURE 3-1b

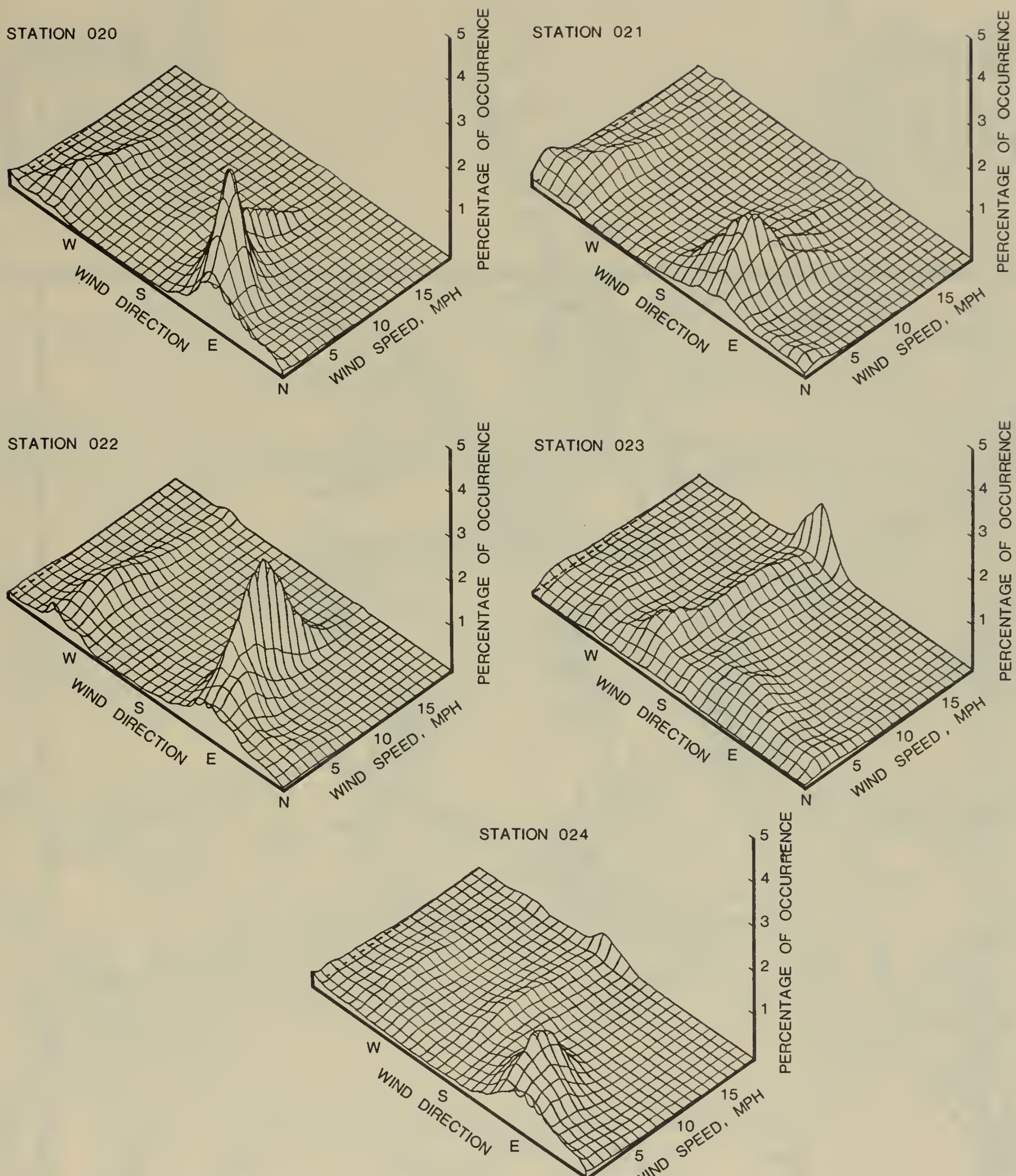
The katabatic and anabatic influences were both evident at Station 024, which is located in a transition zone between the meteorological conditions of the Piceance Creek valley and those of the plateau. The anabatic flow generally affected all five monitoring sites to varying degrees and the katabatic flow generally affected only the lower elevations. On the nights and the mornings when this drainage or katabatic flow was well developed, it affected the valley stations as well as Station 024 and the 8- and 30-foot levels of the meteorological tower.

To obtain additional insights as to the statistical nature of the wind field over and above that presented on the above-referenced wind-roses, 3-dimensional maps of the percentage of occurrence of winds by speed and by direction are presented on Figure 3-2 for all trailer stations.

It is also useful to depict the diurnal wind patterns on a map. November 1975 was selected as a representative month; 5 a.m. MST was selected as a representative hour characterized by downslope flow and 1 p.m. MST as characterizing upslope. Inasmuch as diurnal flow development is particularly dependent on cloudiness, the days were classified as "clear," "cloudy," or "total" (clear and cloudy) at each of these hours. The degree of cloudiness was determined from the pyranometer reading in November at 2 p.m. An hourly value of 36 Langleys was equated to full sunlight and $\geq$22 Langleys assumed to be "clear" for the purposes of this correlation.

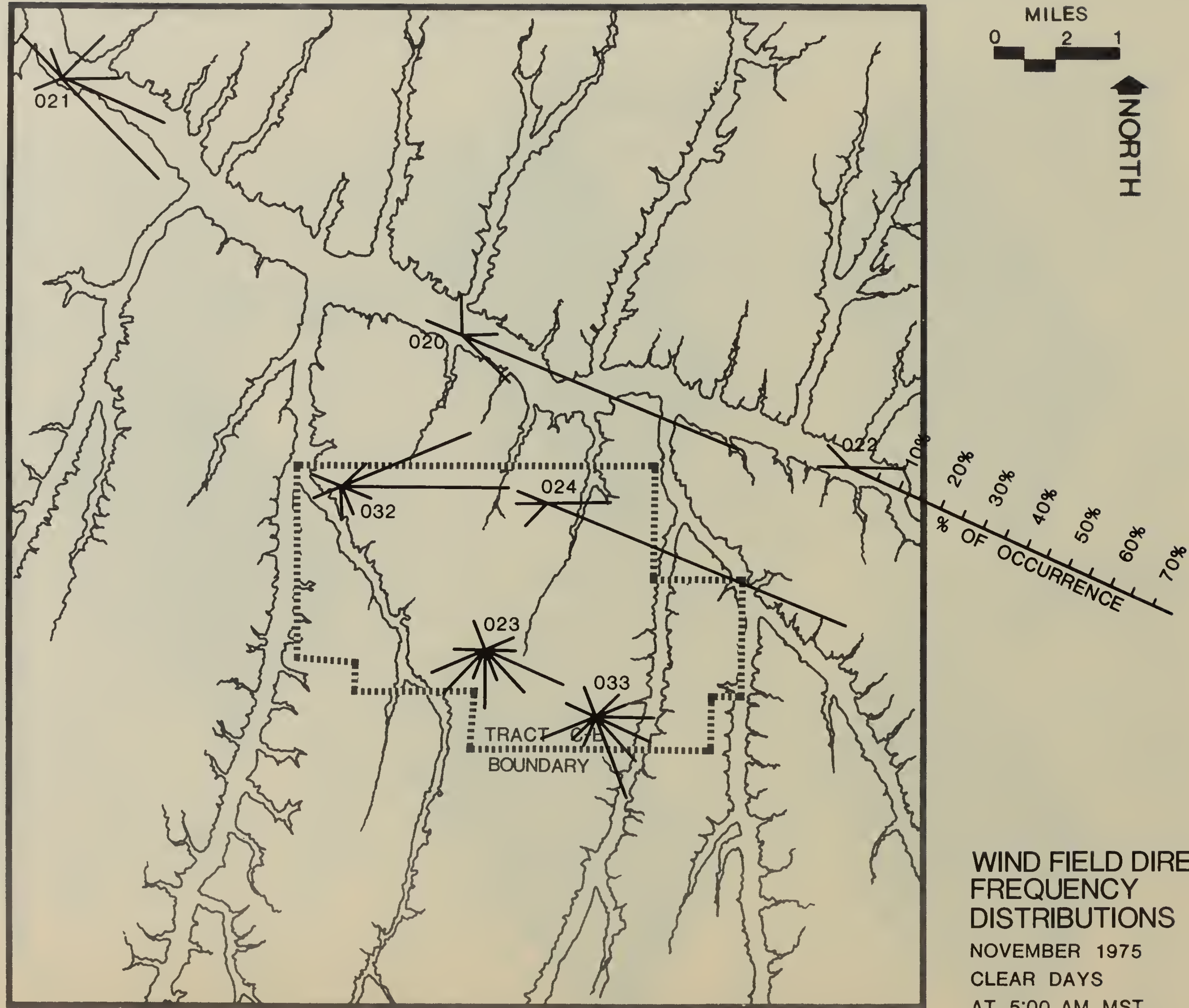
Direction-only wind-roses are portrayed on this November map on Figure 3-3 for "clear" days at 5 a.m. and on Figure 3-4 for clear days at 1 p.m. Similar maps are presented in the appendix, Section B.1.1, for "total" days and for "cloudy" days. These diurnal patterns are typical of flow over the 24-month period, qualified by the previous general flow description. Monthly-averaged direction-only wind-roses are presented in the appendix for selected trailer and mechanical weather stations which also reinforce the preceding descriptive section.

Representative winter (January 1976) and summer (July 1976) wind velocity vectors have also been calculated along with November 1975 as typical nighttime (5 a.m.) and daytime (1 p.m.) vectors on Figure 3-5. Grand Junction vectors for November 1975 are shown for reference at a height of 750 mb. at midnight and noon. The met tower on this figure is designated M100. This figure reinforces the previous qualitative statement that katabatic (downslope) flow is best developed on clear, cold nights; anabatic flow is developed in the afternoons, more strongly in the summer months. Even though flow at the met tower is more "synoptic-like" than other stations, significant



TWO YEAR SUMMARY OF TRAILER WIND DATA FOR '74-'76, % OF OCCURRENCE OF 5 MINUTE SAMPLES AS FUNCTIONS OF WIND SPEED AND DIRECTION

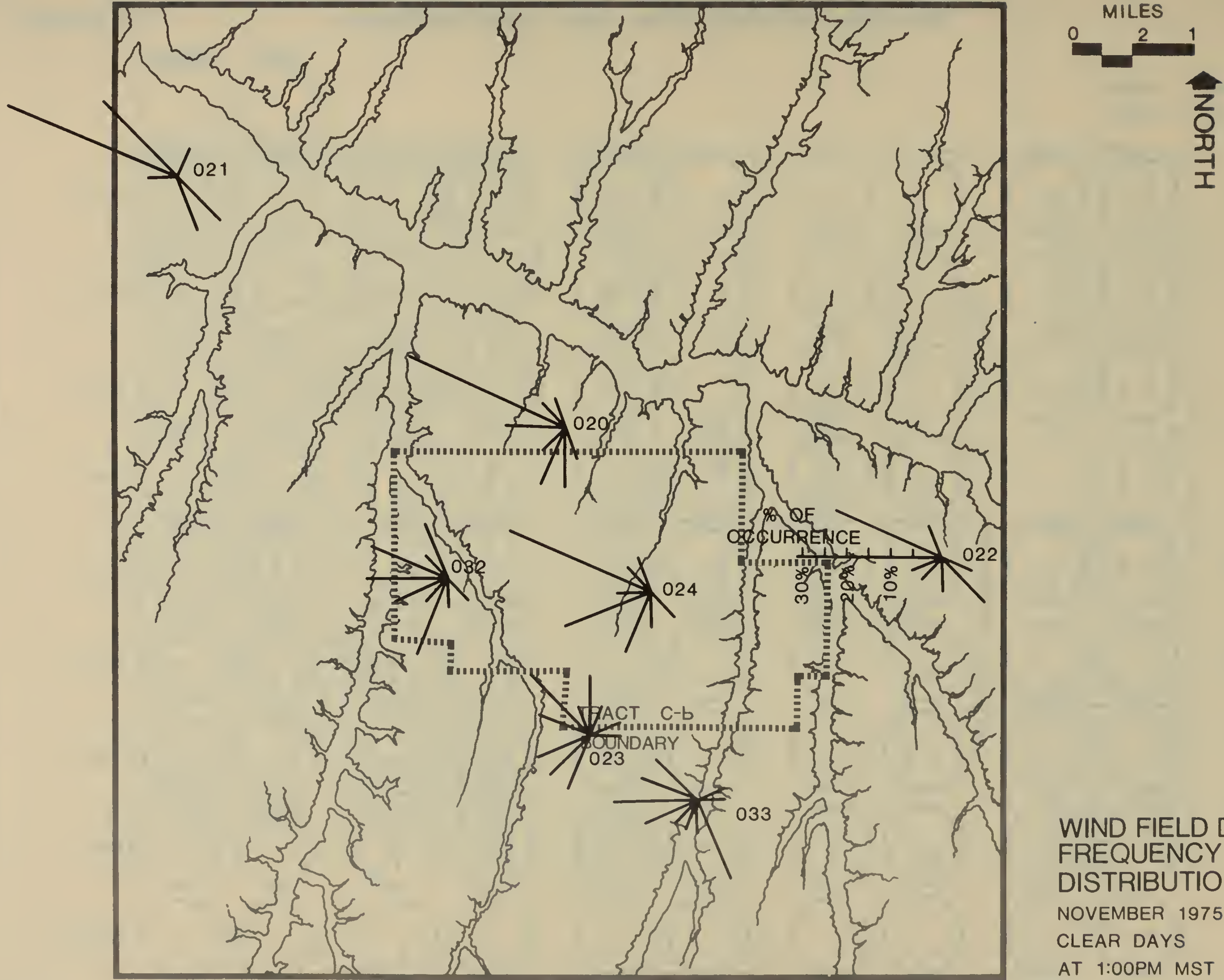
FIGURE 3-2



WIND FIELD DIRECTION
FREQUENCY
DISTRIBUTIONS

NOVEMBER 1975
CLEAR DAYS
AT 5:00 AM MST

FIGURE 3-3



WIND FIELD DIRECTION
FREQUENCY
DISTRIBUTIONS
NOVEMBER 1975
CLEAR DAYS
AT 1:00PM MST

FIGURE 3-4

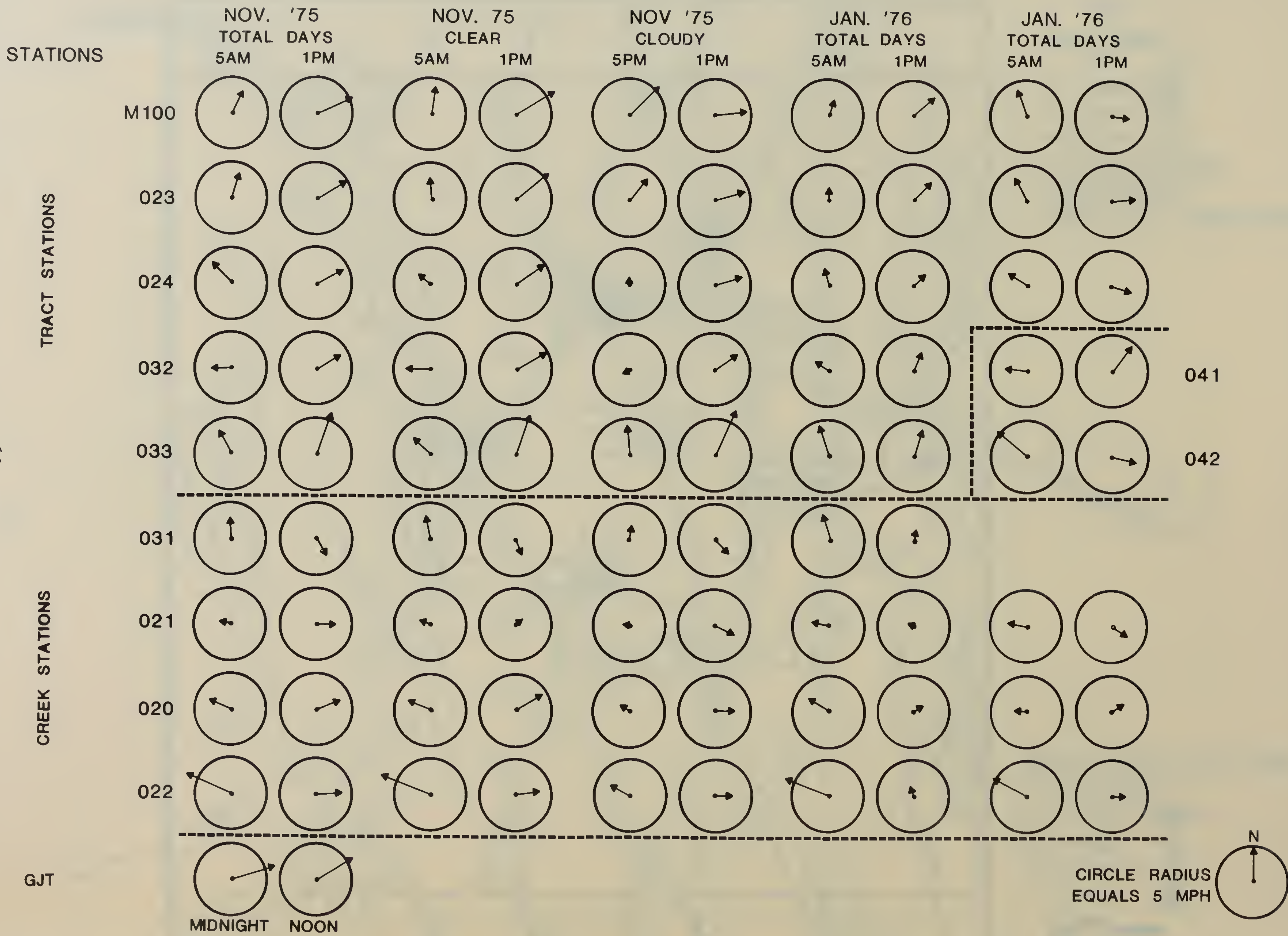


FIGURE 3-5 REPRESENTATIVE WIND FIELD VELOCITY VECTORS

correlation existed between it and Grand Junction only at 1 p.m.

A question of interest relative to air-diffusion modeling in rough terrain is the degree to which the wind direction at given locations can be predicted statistically over extended periods knowing the wind direction at one location at that time. To answer this question a wind-field correlation study was undertaken again using November 1975 ("total," "clear," and "cloudy") as representative. However, these data were further subdivided into

Day = hours from 1100 to 1700 hours inclusive
(for which upflow existed);

Night = hours from 2100 to 0700 hours inclusive
(for which downflow existed);

Transition 1 = flow transition hours
from down - to upflow
0800 to 1000 inclusive;

Transition 2 = flow transition hours
from up - to downflow
1800 to 2000 inclusive.

Paired station correlations with the meteorological tower at 100 feet (M100) are summarized in Table 3-1; a more complete correlation discussion is presented in the appendix in Section B.1.1.

Shown are the results of the correlation studies by the principal data groupings of Tract versus Piceance Creek valley stations, day versus night, and clear versus cloudy conditions. In the case of Piceance Creek valley stations, comparisons were also made with up-stream and down-stream creek directions at each station. The following conclusions are drawn from the study: (1) All coefficients of correlation shown in the table are statistically significant at the 95 percent confidence level indicating that direction shifts at the meteorological tower correspond to direction shifts at each station.
(2) There is a shift in meteorological tower direction from southwesterly on clear days to southwesterly on clear nights. This shift is not indicated under cloudy conditions.
(3) Correlations between meteorological tower and stations are higher in daytime than at nighttime under all conditions.
(4) Correlations are slightly higher during cloudy conditions.
(5) Correlations are higher with Tract stations than with creek stations. (6) Nighttime directions at the creek stations

Table 3-1

SUMMARY OF TRACT AND PICEANCE CREEK STATION WIND FIELD DIRECTION CORRELATIONS WITH THE METEOROLOGICAL TOWER AT THE 100-FOOT LEVEL

(November 1975)

CONDITION	PARAMETER	TRACT STATIONS NO.	TRACT STATIONS DAY	TRACT STATIONS NIGHT	CREEK STATIONS NO.	CREEK STATIONS DAY	CREEK STATIONS NIGHT
	Tower	M100	213°	161°	M100	213°	161°
CLEAR	Correl Coef	Ave	.94	.65	Ave	.89	.52
	Mean Direction	Ave	207	132	Ave	NA	NA
						US* STA	DS* STA
	Dir/Coef	023	204/.99	163/.69	031	352-185/.85	172-169/.46
	Dir/Coef	024	210/.96	124/.67	021	314-221/.92	134-119/.48
	Dir/Coef	032	214/.93	100/.70	020	295-209/.96	115-121/.53
	Dir/Coef	033	201/.86	144/.53	022	291-218/.84	111-132/.62
	Tower	M100	201°	206°	M100	201°	206°
CLOUDY	Correl Coef	Ave	.96	.75	Ave	.91	.67
	Mean Direction	Ave	189	167	Ave	NA	NA
						US* STA	DS* STA
	Dir/Coef	023	194/.99	192/.84	031	352-195/.89	172-192/.58
	Dir/Coef	024	192/.99	159/.77	021	314-176/.91	134-141/.66
	Dir/Coef	032	190/.90	148/.72	020	295-191/.92	115-144/.72
	Dir/Coef	033	181/.97	167/.49	022	291-186/.93	111-141/.73

*NOTE: US is Piceance Creek up-stream direction. DS is down-stream direction.
STA is station mean direction.

correspond generally to down-stream creek directions under both clear and cloudy conditions, but more closely on clear nights when drainage flow is better established. (7) Creek station wind directions in the daytime more closely approximate the meteorological tower directions than at night. (8) Coefficients of correlation between creek stations and meteorological tower are higher in daytime than at night; this correlates with the fact that katabatic flows in the creek are better established in winter than anabatic, with the former being more independent of tower direction.

Still another question related to atmospheric diffusion is that of wind direction persistence at specified atmospheric stability categories. Discussion of techniques to determine these stability categories are deferred to the next section. It needs to be noted, however, that atmospheric stability may vary with hour of the day, season of the year, and height above the surface. The heights above the surface that are of most interest are those which characterize the centerline of the (estimated) pollutant plumes (including effects of plume rise); these are estimated to vary from ground level emission sources to those up to about 1000 feet. Extensive studies have been conducted to tower-top levels of 200 feet; the information base at higher elevations is incomplete. This discussion is based on data obtained from the 200 foot meteorological tower alone. Utilizing the temperature differences on the tower from 200- to 30- feet, Pasquill-Gifford atmospheric stability classes were determined. Then over the entire first year of baseline winds at a tower level of 200 feet were systematically categorized by direction sector for each hour by stability class. For each stability class and wind-direction sector hourly sequences were scanned and ranked for persistence of direction. Highest persistence durations then became candidates for the so-called "worst-case" meteorological conditions for input to atmospheric diffusion models which predict ground levels of air pollution from the oil shale plant. This entire procedure was repeated for the second year of baseline and then combined to form the composite of the two years of baseline. Thus six stability classes for the first year, six the second and six for the composite yields eighteen such summary tables, which are shown in the appendix, Section B.1.1. One such typical table for F stability for the two years of baseline which did yield the "worst-case" conditions actually modeled is shown on Table 3-2; the worst-case was a south-southwest wind of a six-hour duration persistence on June 5, 1975. Longest persistence to date has been 27 hours of SSW winds at D stability on February 7-8, 1975.

Wind magnitudes are of interest both in terms of averages and extremes. The annual average of the hourly-mean speeds

Table 3-2 WIND PERSISTENCE AT SPECIFIED STABILITY
November 1974 - October 1976

Stability F

Direction	Max. Duration Hrs. / Date				
N	2 / 6-7-75	2 / 10-18-75	2 / 11-6-75		
NNE	2 / 6-4-75	2 / 9-22-75			
NE	3 / 8-30-75	2 / 8-9-75	2 / 8-10-75		
ENE	2 / 5-17-75	2 / 8-29-75	2 / 9-22-75	2 / 9-24-75	
E	3 / 1-23-75	3 / 8-3-75	2 / 8-30-76		
ESE	3 / 2-17-75	3 / 8-3-75	3 / 9-5-75		
SE	6 / 2-23-76	5 / 10-1-76	4 / 5-14-75	4 / 8-10-75	3(1) / 12-3-75
SSE	4(1) / 12-3-75	3 / 8-4-75	3(3) / 10-6-75		
S	5 / 1-19-75	4 / 6/1-6/2-76	4(3) / 10-6-75	3(2) / 6-5-75	
SSW	6(2) / 6-5-75	5 / 10-5-75	4 / 5-28-76		
SW	4 / 1-23-75	4 / 9-6-75	3 / 10-31-76		
WSW	3 / 9-17-75	2 / 6-5-75			
W	4 / 5-16-76	2 / 8-8-75	2 / 6-27-76		
WNW	3 / 9-17-75	3 / 9-21-75			
NW	2 / 1-1-75	2 / 1-29-75	2 / 8-2-75	2 / 9-29-75	
NNW	2 / 1-1-75	2 / 9-29-75			

Footnotes:

(1) The wind pattern of SE-SE-SSE-SSE-SSE-SE-SSE was credited as 4 continuous hrs.-SSE wind and 3 consecutive hrs. SE wind.

(2) 6 hrs. @ SSW and 3 hrs. @ S.

(3) 3 hrs @ SSE and 4 hrs.@ S.

ranged from 5 mph in Piceance Valley to 8 mph at Station 023 at 30 feet. Mean speeds for each month at all stations are presented in the appendix, Section B.1.1. Peak 5-minute speeds have reached the 56-60 mph range only twice at the 200 foot level in two years; the probability that 5-minute gusts will exceed 40 mph is 1.8×10^{-4}. Probabilities were estimated from two years of baseline data.

3.1.1.5.2 Vertical Structure of the Wind and its Variations

Speed generally increases with height. Table 3-3 shows mean hourly values of wind speed for each month at each level of the tower. This speed variation with height has been approximated by a logarithmic fit, the constants of which (and equation) are shown on the table. As one point of comparison with our estimated value for the roughness length (z_0) of 0.22 feet, Sellers 1965 lists (typically) 4.17 feet for corn, 0.76 for wheat, 0.02 to .51 for grasses and 0.001 for smooth desert in his Table 20.

A "macro" view of the vertical wind structure has been obtained from the quarterly pibal upper air studies utilizing a single theodolite. Table 3-4 shows these average wind speeds and directions to heights of 13,000 feet. The seasonal velocity vector data presented in Table 3-4 showed the expected increase in wind speed with altitude although there are three exceptions. The decrease in average wind speed between 12,000 and 13,000 feet above MSL for the spring season was probably an indication that the upper level gradient flow extended down to below these levels. The low altitude (9,000 to 10,000) decreased wind speed with height during the fall sampling period may be associated with the high frequency of occurrence of sounding days associated with precipitation during the fall study. All seasons showed the general clockwise turning of the wind direction with height. The summer and fall wind speeds were significantly lower than the corresponding speeds during winter or spring.

In an intensive examination of both the vertical and horizontal structure of the wind fields a ten day tethersonde study was conducted at Stations 023 and 020. Typical wind flow data at Stations 020 and 023 are shown in Figures 3-6 and 3-7. Wind velocity is indicated in Figure 3-6 by the small arrows on the left side of each of the sounding plots. The ordinate value of the dot at the center of each arrow is the height of the observed wind in feet above the surface. The abscissa of the point as read on the scale at the top of the plot is the wind speed in miles per hour. Wind direction is indicated by the direction of the arrow; it points in the direction of flow on a

Table 3-3 METEOROLOGICAL SUMMARY: VERTICAL VARIATION IN HORIZONTAL WIND PROFILE LEVELS (Met. Tower) 1974-1975

Height on Tower (Feet) (z)	Arithmetic Mean Hourly Wind Speed for the Month												Annual
	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	
8	4	5	5	5	7	7	6	6	4	5	4	6	5.3
30	7	7	8	8	10	10	9	8	7	8	6	8	8.0
100	8	9	10	10	12	11	11	10	8	10	7	10	8.8
200	8	9	10	10	13	12	11	10	8	10	7	11	9.9
Constants for Logarithmic Fit (1)													
v^*/k (MPH)	1.26	1.39	1.57	1.57	1.95	1.85	1.70	1.57	1.26	1.57	1.09	1.57	1.53
v^* (MPH)	0.50	0.56	0.63	0.63	0.78	0.74	0.68	0.63	0.50	0.63	0.44	0.63	0.61
z_0 (ft.)	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22

1975-1976

Height on Tower (Feet) (z)	Arithmetic Mean Hourly Wind Speed for the Month												Annual
	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	
8	5	4	4	7	6	6	5	7	5	6	4	4	5.3
30	7	6	5	9	8	8	7	9	6	9	6	5	7.1
100	9	7	6	11	10	10	8	11	8	11	7	6	8.7
200	10	7	7	12	10	11	9	12	8	11	7	7	9.3
Constants for Logarithmic Fit (1)													
v^*/k (MPH)	1.41	1.09	1.04	1.83	1.57	1.57	1.39	1.83	1.26	1.72	1.09	1.04	1.41
v^* (MPH)	0.56	0.44	0.42	0.73	0.63	0.63	0.56	0.73	0.50	0.69	0.44	0.42	0.56
z_0 (ft.)	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22

(1) Assumed form of equation:

$v(z) = \frac{v^*}{k} \ln (z/z_0)$ where $v(z)$ = Mean wind speed at height z above surface
v^* = Friction velocity
z_0 = Roughness length
k = von Karman's constant = 0.4

Table 3-4 SEASONAL AVERAGE WIND SPEED AND DIRECTION FOR SELECTED ELEVATIONS FROM PIBAL UPPER AIR STUDIES (FEET ABOVE MSL)

	AVERAGE WIND SPEED/DIRECTION AT:						
SEASON	8000'	9000'	10000'	11000'	12000'	13000'	AVE.
Fall	4/251	7/243	6/254	9/259	10/251	10/277	7/258
Winter	15/221	17/238	22/245	24/258	26/261	29/267	21/252
Spring	12/207	12/218	14/221	16/236	23/234	21/234	16/227
Summer	4/218	4/235	4/268	5/289	5/285	5/294	4/269
ANNUAL	9/219	10/232	11/241	13/254	15/252	16/260	12/246

Note: Units (MPH/Degrees)

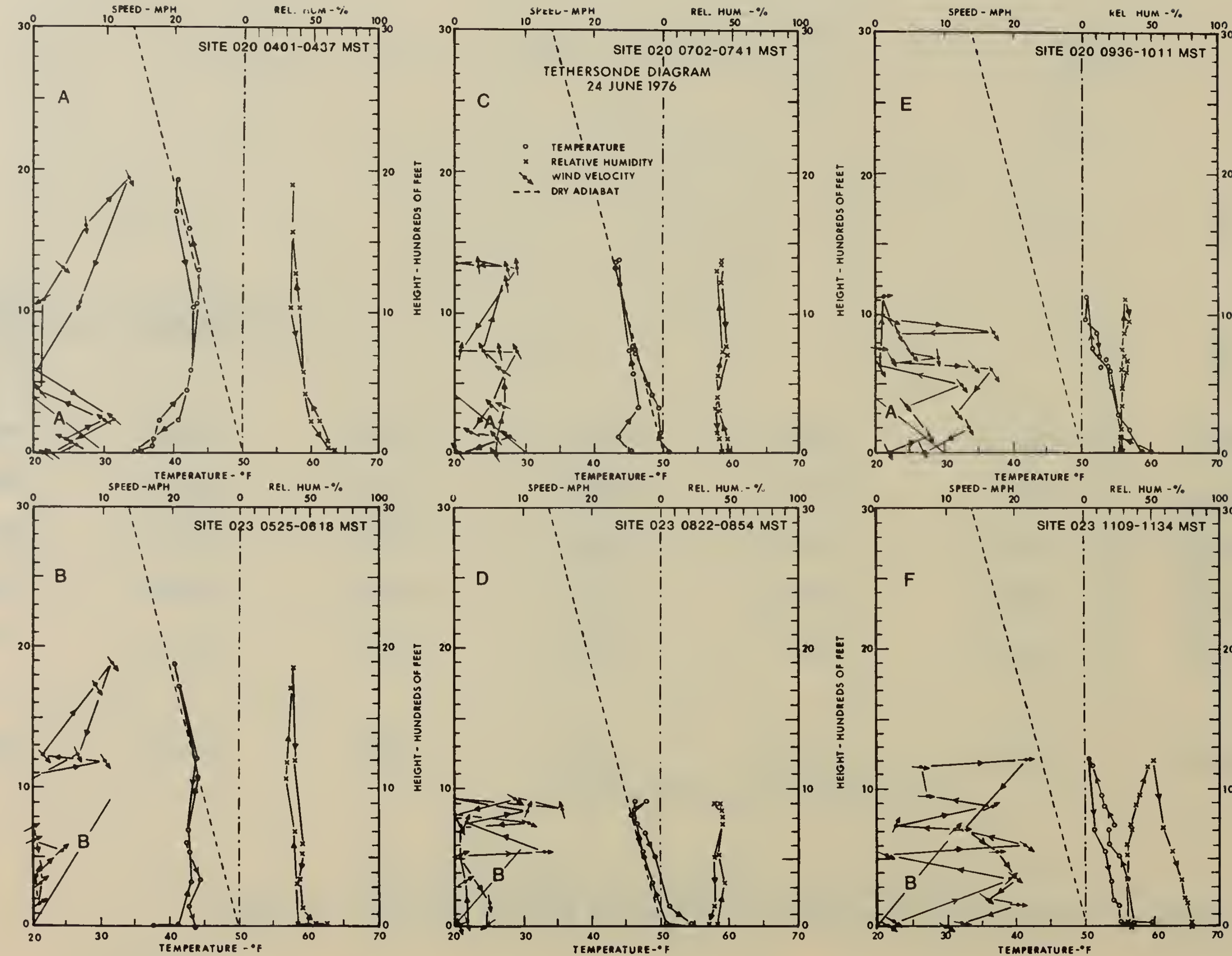


FIGURE 3-6 TYPICAL UPPER AIR STUDIES UTILIZING TETHERSONDES

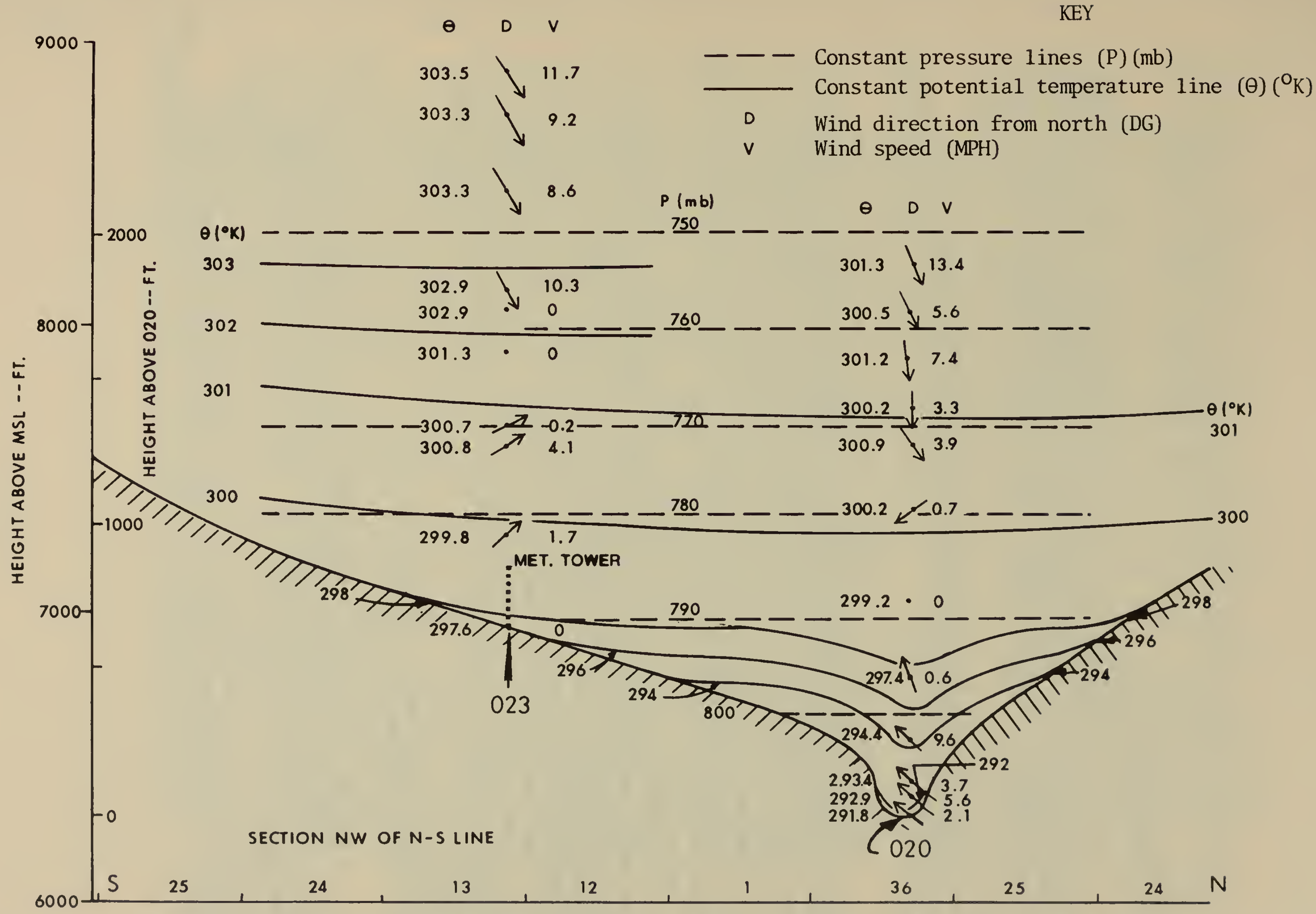


FIGURE 3-7 NORTH-SOUTH TETHERSONDE PROFILE THROUGH STATIONS 020 AND 023 ON 24 JUNE 1976, 0400-0600 MST

compass in the plane of the paper on which north is at the top of the chart. Wind direction is depicted in the same way in Figure 3-7, but speed in miles per hour is written to the right of the wind arrow in the column headed V.

Figure 3-6 describes a transition from typical night flow to equally typical daytime flow. Two soundings, ascent and descent, at Station 020 in the canyon are shown in Figure 3-6a. The descent data are very nearly identical with the ascent. The wind was flowing down the canyon at all levels up to 500 ft. In the stratum above 1,000 ft., winds were from the north to northwest; these were characteristic of the free atmosphere above mountain-top levels. The zone from 500 to 1,000 ft. was a transition zone between two very nearly opposing flows; winds in that zone were very light.

Figure 3-6b shows the soundings taken at Station 023 as soon as possible after the soundings at Station 020 shown in Figure 3-6a. The most fundamental difference is the wind direction in the stratum from the ground up to 700 ft. The winds were blowing down the slope toward the canyon and are nearly perpendicular to the winds in the canyon. It is to be expressly noted that during this stable condition with the near surface winds blowing from the southwest, this same direction was not noted at any elevation above Station 020 in the canyon.

At 0500 MST on 24 June, tower data indicated light winds from a generally south-to-southwesterly direction. Wind blowing over a rough surface characteristically changes direction in a clockwise fashion from the ground upward. Thus, southerly winds at tower level were expected with southwesterly winds at a higher level. This comparison with tower data served two purposes. It showed that the two systems were capable of yielding comparable data, and it also showed that the height to which tower data can be extrapolated was quite limited. For example, there was no indication in the tower data of the calm stratum between 700 to 1,100 ft., nor of the northwesterly winds above that. Even though the tower flow was often "quasi-synoptic," in this instance it bore no resemblance to synoptic flow.

A second pair of soundings taken at Station 020 is shown in Figure 3-6c. Winds were still blowing down the canyon at all levels up to 600 ft. Above that level, winds were more southerly and were blowing across the canyon from the south side. This is in contrast to nearly opposing winds at yet higher levels as shown by all soundings earlier in the morning. Sunrise occurred on the canyon floor about a half-hour before this flight was started. By the end of the flight, some cumulus of fair weather were forming to the southeast. The convective cells associated

with these clouds were starting to create small local circulations which were superimposed on the circulations created by the terrain. The southerly winds observed at the top of these soundings are probably caused by such convective activity.

Figure 3-6d shows that by 0854 MST winds at Station 023 had become highly variable, which is characteristic of flow during periods of convective activity. This same variability was observed at Station 023, again between 1109 and 1134 MST, when the last sounding of the day was made. During this final flight, the balloon encountered strong up and down drafts. There were cumulus of fair weather clouds in all directions at that time.

The most dramatic change in flow to occur during this sequence of soundings was the change from down-canyon flow at 0741 MST to up-canyon flow at 0936 MST, Figures 3-6c and 3-6e.

A discussion of the analytical techniques used in constructing Figure 3-7 is given in Section 3.1.2.5.2 where temperature fields are discussed. However, the figure shows several interesting aspects of wind flow. Above the 301°K isotherm of potential temperature (about 1,000 feet above Station 023), the flow at Stations 020 and 023 was from the north to northwest. This was the direction of the wind in the free atmosphere above. The free flow was interacting with the cold air below, creating turbulence on various scales in both air masses. It is evident that the air aloft was dipping more deeply into the valley at the time of the sounding at Station 020 than at the time of the sounding at Station 023. Flow was from the southwest which was toward the canyon. Since the motion, except that very near the ground, was adiabatic, the flow toward the canyon was along the potential temperature lines. Hence, it had a downward component. Flow toward the canyon from the north side of the valley must have been occurring also, and where the flows met, they turned and became part of the down-canyon flow. At the time of Figure 3-7, flow of this type had reached a quasi-steady state.

The actual transition from night-to-day flow in the canyon is not shown by any of the figures, although it obviously occurred between 0741 and 0936 MST (Figures 3-6c and 3-6e). Since both morning and evening flow transitions are dependent on temperature distributions in the valley, discussion of them is deferred to Section 3.1.2.5.2. This study was an accurate portrayal of the complex nature of the flow field at the Tract; flow fields were neither horizontally nor vertically uniform.

In summary, the near surface wind structure is dominated by terrain influences. The winds in Piceance Creek valley are constrained by the valley walls to a down-creek direction at night

and up-creek by day. Primary wind direction at the tower is south-southwest. Correlations in wind direction at all other stations with the meteorological tower were good for the one typical month examined, being higher at night than during the day and higher for plateau stations than creek stations. Extensive wind persistence studies by atmospheric stability class have been conducted for winds at tower level; at higher heights only selective data are available.

Regarding the phenomenon of valley flow: on a clear night, a katabatic wind sets in soon after sunset. The cold air flow deepens and by dawn, it fills the valley to approximately the level of the tops of the lower mountains to the north. The flow is toward the creek from the higher reaches of the plateau and down the creek at all levels in its immediate vicinity. As the sun starts to warm the ground and cuts off the cold air supply, an anabatic wind sets in near the surface while the cold air aloft continues to flow down the valley. The combination of solar heating and subsidence associated with the cold air outflow warms the valley air and within two or three hours after sunrise, anabatic flow fills the valley and flow on the higher plateau starts to feel the direct influence of winds in the free atmosphere. By this time the lapse rate has become neutral, and vertical mixing is starting to occur to great depths over most of the valley. The anabatic flow and good mixing continue until late afternoon when a surface inversion again forms.

3.1.2 Temperature Fields

3.1.2.1 Rationale

Although wind fields preceded this discussion it is really temperature differences caused by radiational heating and cooling that trigger density differences that, in turn, trigger the local winds. Hence to understand wind patterns one must also understand the temperature patterns which produce the winds. Also, basic climatology is concerned with temperature averages and extremes. Further, one technique for estimating atmospheric stability is based on vertical temperature structure.

3.1.2.2 Objectives

The objectives of the temperature field investigations are to (1) document baseline temperature fields as part of the climatological definition in terms of hourly, daily, and monthly averages and related extremes, and (2) provide vertical temperature structure and its diurnal and seasonal variations to be utilized primarily for atmospheric stability assessment.

3.1.2.3 Experimental Design

The meteorological network of trailers, tower, and MRI stations has been previously described (Figure 2-2); measurement frequencies and data reporting for temperature were identical to those for wind (Section 3.1.1) at these stations. In the tethersonde study measurement frequencies and data reporting were identical to that for wind. Aircraft flight attempts corresponded on both a quarterly and diurnal basis with the previously described pibal releases.

3.1.2.4 Methodology

Detailed tower and trailer instrumentation and data acquisition system descriptions and instrumentation accuracy are included in the appendix in Section A.1, that for the mechanical weather station in A.5, that for the aircraft upper air studies in A.2, and that for the tethersonde studies in A.4.

In summary, the five trailers and three mechanical weather stations were utilized to study horizontal temperature patterns and associated interstation correlations. The meteorological tower, aircraft, and tethersonde were all utilized to obtain vertical temperature structure and associated data on atmospheric stability; the tower has been utilized over the entire baseline whereas the aircraft and tethersonde have been utilized for short-term analyses. For the special case where temperature increases with altitude (defined as an "inversion"), the acoustic sounder has provided continuous information on the height of the top of this inversion to serve as a check with that derived from all three others: tower, aircraft, and tethersonde.

3.1.2.5 Results and Discussion

This discussion first considers as Subsection 3.1.2.5.1 near-horizontal temperature fields. It is followed by a lengthy discussion on vertical temperature structure and its variations as Subsection 3.1.2.5.2. Subsection 3.1.2.5.3 is concerned with atmospheric inversion statistics. Subsection 3.1.2.5.4 covers atmospheric stability considerations, all included here for compactness. The summarizing paragraphs follow this last subsection.

3.1.2.5.1 Near-Surface Temperature Fields

Because of the katabatic effects previously mentioned in the winds discussion, temperatures were often considerably colder in the Piceance Creek valley than on the plateau during relatively calm, clear nights. During these nights, due to radiational cooling, intense ground-based inversions formed. The top of the inversions normally reached elevations that were above the top of the meteorological tower. However, the most stable conditions normally occurred near the ground especially in the Piceance Creek valley. Because of the surrounding valley walls and the relatively low elevation of the site (cold air drainage), Station 021 usually had little vertical mixing and, therefore, normally had the lowest minimum temperatures observed in the network. In fact nighttime temperatures were often 30^{0}F colder at Station 021 than atop the plateau. During the afternoons, when vertical mixing of the air was well established, temperatures were fairly uniform throughout the Tract C-b region. However, afternoon temperatures were slightly lower on the plateau than they were in the Piceance Creek valley. Hourly mean temperature variations for each month as well as hourly maxima and minima are depicted on Figure 3-8. (a, for trailers; b and c for weather stations.) This range of extremes from a -51^{0}F to a +98^{0}F represents one of the widest in the entire U.S. Station 021 exhibited the largest range of hourly extremes (January 1975) from -51^{0}F to +54^{0}F. Maximum hourly temperature measured was 98^{0}F in August 1976; the minimum (occurring in January 1975) was -51^{0}F at Station 021 in Piceance Creek valley.

Strong surface temperature gradients in the mornings have been observed as evidenced on Figure 3-9. For example, at 0600 on January 29, 1975, temperatures of -26, -7, and -8^{0}F were recorded at the Rock School, Redd Ranch, and the Oldland Ranch sites respectively in Piceance Creek valley (6,300 ft. elevation) and +11^{0}F at the meteorological tower site (6,980 ft.). This surface temperature gradient existed during the presence of an extremely strong surface inversion. The strongest vertical temperature gradient (i.e., the inversion) occurred at Rock School where the canyon walls are steepest and drainage effects are strongest. At this same time period (actually 0912 on February 2), a constant-altitude aircraft flight at 7200 ft. MSL was made from directly over Rock School to the C-b tower site indicating no horizontal temperature gradient at that elevation even though one existed in the valley. Thus the inversion was shallow and limited to only the valley region. An additional flight was made at 0810 MST on February 9, when no surface inversion existed, up Piceance Creek valley from Rock School to the Oldland Ranch at a near-surface altitude of 6,400 ft. MSL indicating less than 1^{0}F horizontal gradient. Thus the con-

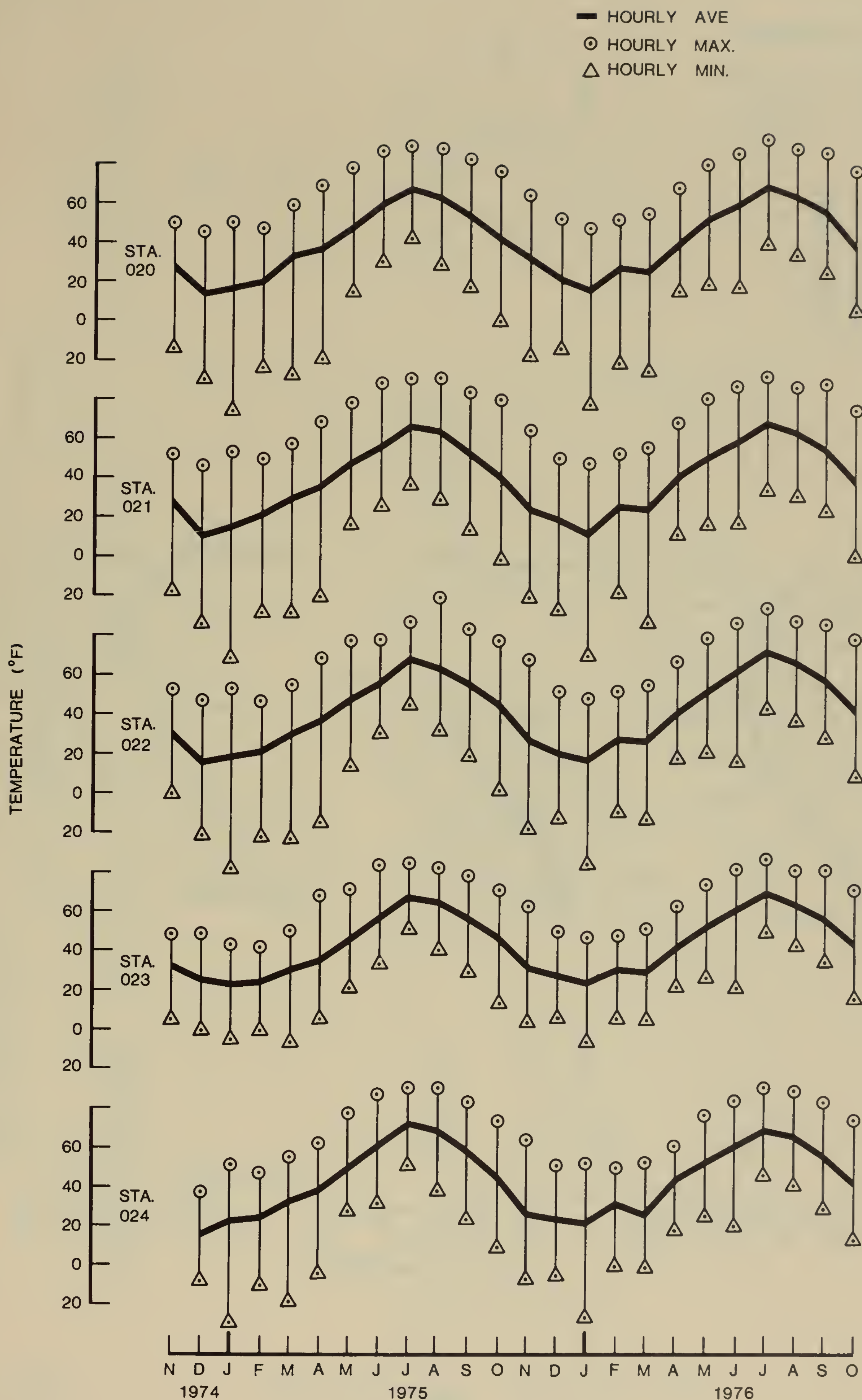


FIGURE 3-8a

AIR TEMPERATURE VARIATIONS

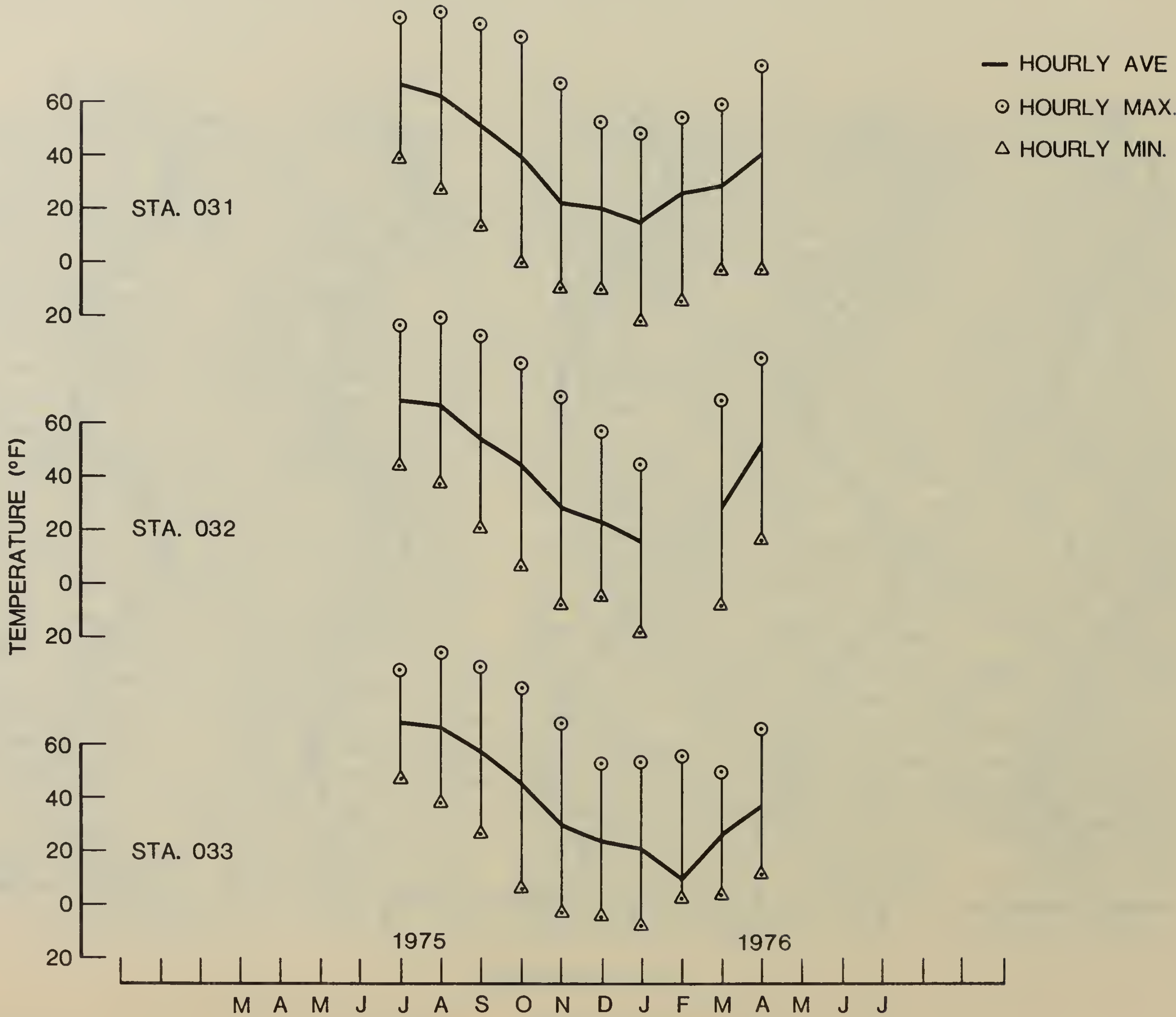


FIGURE 3-8b

AIR TEMPERATURE VARIATIONS

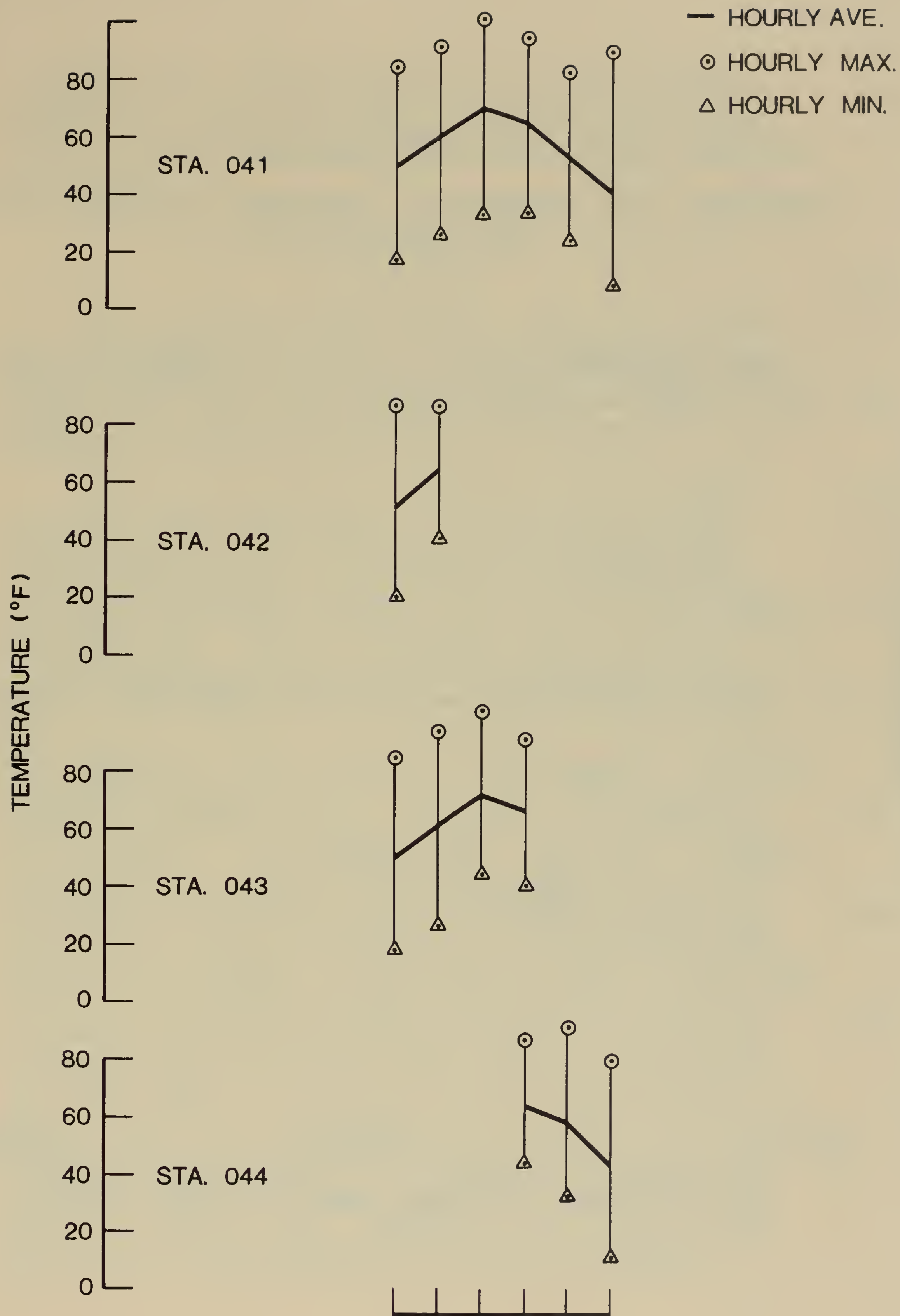
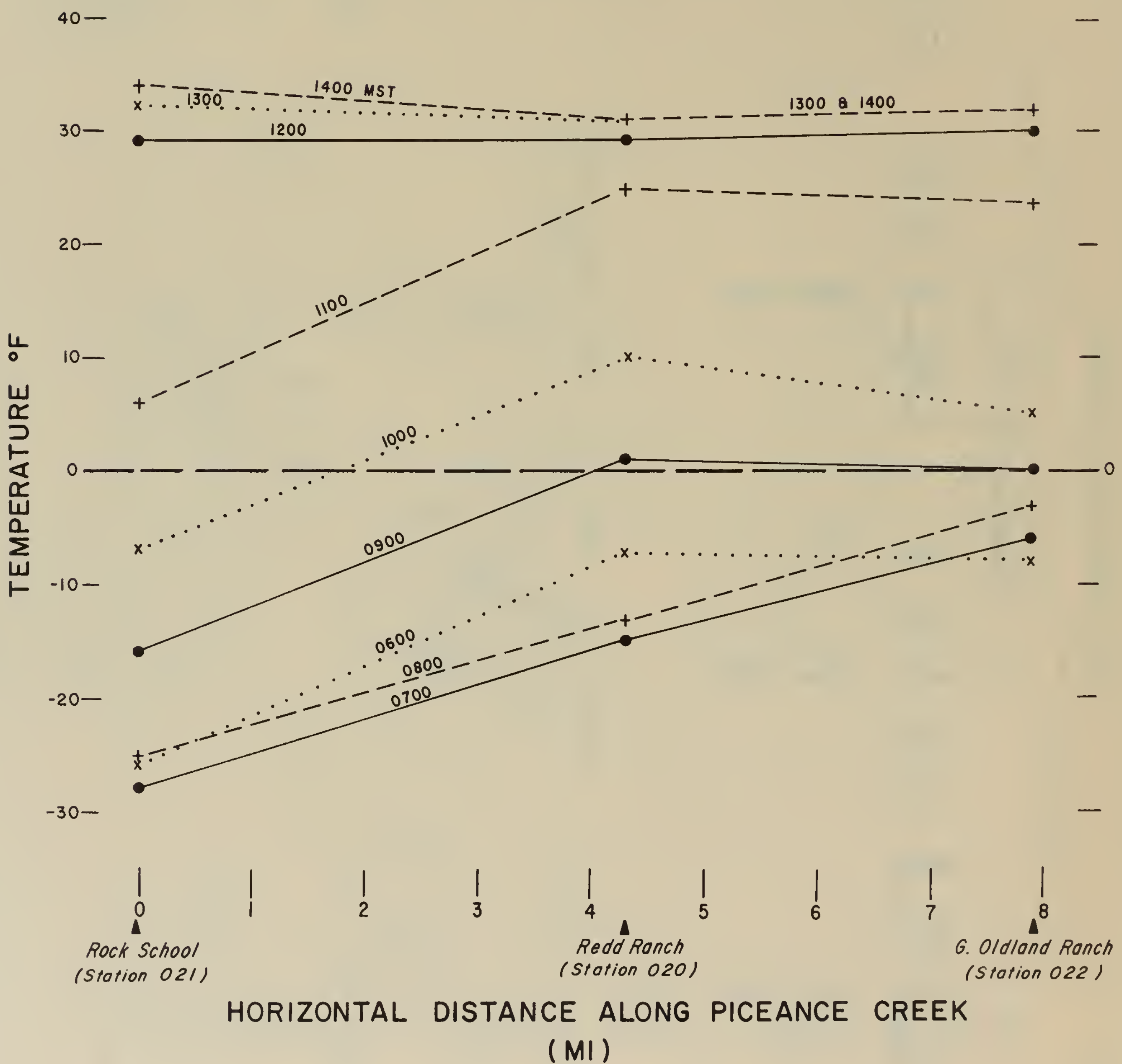


FIGURE 3-8c AIR TEMPERATURE VARIATIONS 1975

FIGURE 3-9

HORIZONTAL AIR TEMPERATURE VARIATIONS IN PICEANCE VALLEY
29 JANUARY 1975



clusions of this complex pattern were that large horizontal gradients were confined to lower levels in the valleys and existed there only in the presence of ground-based inversions. When the inversion dissipated, the horizontal gradient diminished to near zero.

3.1.2.5.2 Vertical Temperature Structure and its Variations

The previous paragraph discussed a typical early morning horizontal temperature gradient in Piceance Creek valley. Vertical gradients varied substantially over the diurnal cycle. Monthly variations in the hourly-mean temperatures on the meteorological tower are of interest to portray average vertical temperature structures and are presented on Table 3-5.

Variations in vertical temperature structure have been studied over the long term up to 200 feet above the surface utilizing data from the meteorological tower; up to approximately 3,000 feet the top of inversions have been estimated from continuous acoustic sounder data. Aircraft data provided insights to 13,000 feet above the surface in four 15-day studies in each quarter. A ten-day tethersonde study has provided valuable detailed insights to heights of 2,200 feet above the surface. The following discussion incorporates data from all these sources, starting with details from the tethersonde study.

Figure 3-6 of the tethersonde study illustrated a typical transition from night to day in summer when skies throughout the night had been clear. In all of the plots on this figure, the dashed diagonal line is the dry adiabat or an isoline of potential temperature. The temperature lapse rate within a stratum of air which is well mixed in the vertical will be parallel to the adiabat. A stratum in which the temperature-versus-height curve is more nearly vertical than the adiabat or which slopes upward and to the right is hydrostatically stable, and air from one level does not mix readily with air above or below it. A stratum in which the temperature decreases more rapidly with increasing height than the adiabat is unstable. It is likely to overturn, and air from one level within such a stratum will mix readily with air from other levels. Such lapse rates are termed superadiabatic. They are frequently found near a warm earth's surface; they are not frequently found far from the surface except as thin transitory phenomena which result from dynamic instability. Mixing in a superadiabatic stratum transports heat upward. In general, however, motions of air except those very near the earth's surface are nearly adiabatic, and hence the air flows along potential temperature surfaces.

Table 3-5 MEAN TEMPERATURE PROFILES ON THE MET. TOWER (DEG F)

1974-1975

Height on Tower (Feet)	Hourly Mean Temperature for the Month												Annual
	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June (1)	July	Aug.	Sept.	Oct.	
8	32	24	21	23	31	34	44	50	70 (1)	62	54	46	40.9
30	32	25	23	24	31	35	46	56	67	65	56	47	42.3
100	33	25	23	24	30	34	45	56	67	65	57	47	42.2
200	33	26	23	24	30	34	44	51	69 (1)	65	56	46	41.8

1975-1976

Height on Tower (Feet)	Hourly Mean Temperature for the Month												Annual
	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	
8	31	27	24	31	29	41	51	59	67	63	55	43	43.4
30	32	28	24	32	30	42	52	60	69	64	56	43	44.3
100	31	27	23	31	28	40	51	59	68	64	56	43	43.4
200	31	27	22	30	28	40	51	59	68	63	55	42	43.0

(1) Partial Data Only

In Figure 3-6a the temperature lapse rate was stable up to 1,300 ft. during ascent and below 1,100 ft. during descent. Above about 1,200 ft. it was nearly adiabatic up to the top of the sounding during ascent. During descent a shallow, stable stratum was evident at the top of the sounding, and the air was cooler in the layer from 1,700 ft. to 1,000 ft. than it had been a few minutes earlier during ascent. This change was less than two degrees, but it does illustrate that change can occur in the transition layer between the cold surface air and the free atmosphere even when the atmosphere above and below is in a quasi-steady state. The term "inversion" is often associated with the nighttime lapse rate. In these soundings the base of the nocturnal inversion is on the surface; the top is at the level where the temperature ceases to increase with increasing height.

The effect of solar heating is clear in these soundings. Before sunrise a deep ground-based inversion existed at both Stations 020 and 023. Sunrise occurred on the floor of the canyon about a half-hour before the sounding plotted in Figure 3-6c was started. By launch time a shallow superadiabatic layer had formed adjacent to the ground, and by the end of the flight the entire stratum traversed was adiabatic. This was in marked contrast to the deep inversion which had existed three hours earlier. The warming continued, and the layer remained adiabatic except for a shallow surface-based super-adiabatic stratum. The air was undoubtedly well mixed throughout the lowest 1,200 ft.

At Station 023 (Figures 3-6b, 3-6d, and 3-6f) the change was essentially identical with that at Station 020 through the ascent of the last flight (Figure 3-6f). During that last flight, however, cooling occurred and the relative humidity increased markedly. Cumuli of fair weather clouds were observed in all directions and were affecting the atmosphere in the vicinity of the tower in several ways. The balloon experienced strong up and down drafts and gusty winds during flight. The cooling and change of humidity observed during this flight were probably caused by the convective activity and were short-lived Tower temperatures, for example, increased from 1100 to 1200 MST.

Another form of graphical display shows many of the features previously discussed. Figure 3-7 is a vertical cross-section taken in a north-south direction through Stations 020 and 023. The terrain profile is highly smoothed but it shows the general slope of the ground from both north and south, and it shows the much steeper walls of the canyon in which Piceance Creek flows. North is on the right so that the viewer is looking down the canyon. The horizontal distance unit along the bottom of the

chart is one statute mile. The numbers of the sections immediately west of the north-south section line on which the profile is based are shown along the abscissa. Height in feet is given along the left side of the chart, using two scales. The outer scale is height above sea level; the inner scale is height above Station 020. Stations 020 and 023 are taken as 6,325 ft. and 6,960 ft., respectively, above mean sea level. The data plotted above the locations of the two stations are identified by symbols at the top of each data column. Potential temperature (θ) is in degrees Kelvin, wind speed (V) is in miles per hour and wind direction is indicated by an arrow pointing in the direction of the wind flow using a compass on which north is the top of the chart. When wind speed is zero, no direction arrow is given.

Isolines of θ are the solid lines. Isolines of pressure (isobars) are dashed lines. The θ lines are labeled along the margins of the chart. The isobars are labeled near the center.

In analyzing a chart of this type one takes advantage of knowledge of how meteorological variables are typically distributed above the earth's surface. For example, over such short distances as the horizontal dimension of this valley, pressure surfaces will be so nearly horizontal that it would be difficult to measure their slope even with the best of barometers. Therefore, isobars should be drawn as horizontal lines. Pressure was plotted at each height on a separate chart and the isobaric analysis was transferred to this chart. Hence pressure data were not plotted on the chart.

Similarly, θ surfaces in the free atmosphere well above the mountains will be virtually horizontal unless disturbed by a frontal surface. Near the cold ground, however, θ surfaces over ground which do not have anomalous hot or cold spots will have a slope similar to the slope of the ground, but not as steep. There, θ isolines will nearly parallel the surface where they approach the surface. They will depart slowly from the surface in the downhill direction. Over a ridge they should be horizontal, and at great heights over a valley they should be horizontal. In general, in the absence of some sort of disturbance, the further from the ground a θ isoline is found, the more nearly horizontal it should be.

With these guidelines in mind, the tethersonde data from the two stations were analyzed to yield the pattern presented in Figure 3-7. First, the data showed that the θ lines slope downward in the lower strata from Station 023 to 020. Since the winds in these strata at Station 023 are toward Piceance Creek valley, air (and any pollutants it may contain) will descend as it moves northward unless it gains heat. If heat is gained

(lost), the air mass can cross potential temperature surfaces toward greater (lower) values, but, since there is no heat source to warm the air, it will descend. Near the ground air will lose heat to the cold ground. Hence near the ground air may cross isotherms of potential temperature toward lower values. The valley influence was clearly manifested at Station 020 up to the 300^0K isotherm. At Station 023 the valley exerted influence at least as high as the 300.7^0K isotherm. A strong θ inversion extended as high as the 303^0K isotherm at Station 023 and the 301^0K isotherm at 020. It is apparent that a significant change in θ occurred at the highest levels reached at Station 020 during the time between soundings, since gradients of over 2^0K in the short distance between stations are not likely in the free atmosphere. There is not enough information at higher levels to permit an assessment of what occurred. Most important, whatever the cause, it does not appear to have seriously affected the flow or the distribution of potential temperature in the valley. This attests to the ability of the valley to influence local temperature and flow.

The aircraft temperature soundings provided insight into temporal temperature changes and vertical air motion. At night, cooling near the surface caused cold air to flow toward and down the creeks. Early in the evening the cold air flowed in more rapidly from its many sources than it could flow out through the creek; consequently it deepened in the valley until the increased hydrostatic head and the larger outflow area equalized outflow and inflow. The data did not show when this happened, but the limited aircraft and tethersonde data suggested that the cold air depth did not increase after 0300 MST.

At sunrise, the ground starts to warm and the cold air source is turned off. Further warming causes the air adjacent to the surface to start flowing up the slopes, including the creeks when the sun reaches creek bottoms. The cold air which has filled the valley for several hours continues to flow out the lower end of the valley so that the valley is being emptied by the two flow mechanisms: the surface flow up the slopes and outflow from the lower end. The entire cold air mass settles and warms; the warming is caused by both solar heating and the warming which accompanies the increase in pressure the air experiences as it descends. These two mechanisms were typically shown in Figure 3-10; additional plots are presented in the appendix in Section B.1.2.

Points 1 and 2 of Figure 3-10 are joined by an arrow. These points were in the free air well above the valley moving so that the air at Point 1 could not have remained in the area and descended to Point 2. The soundings in the free atmosphere were so similar at 0823 and 1119 MST, however, that it was

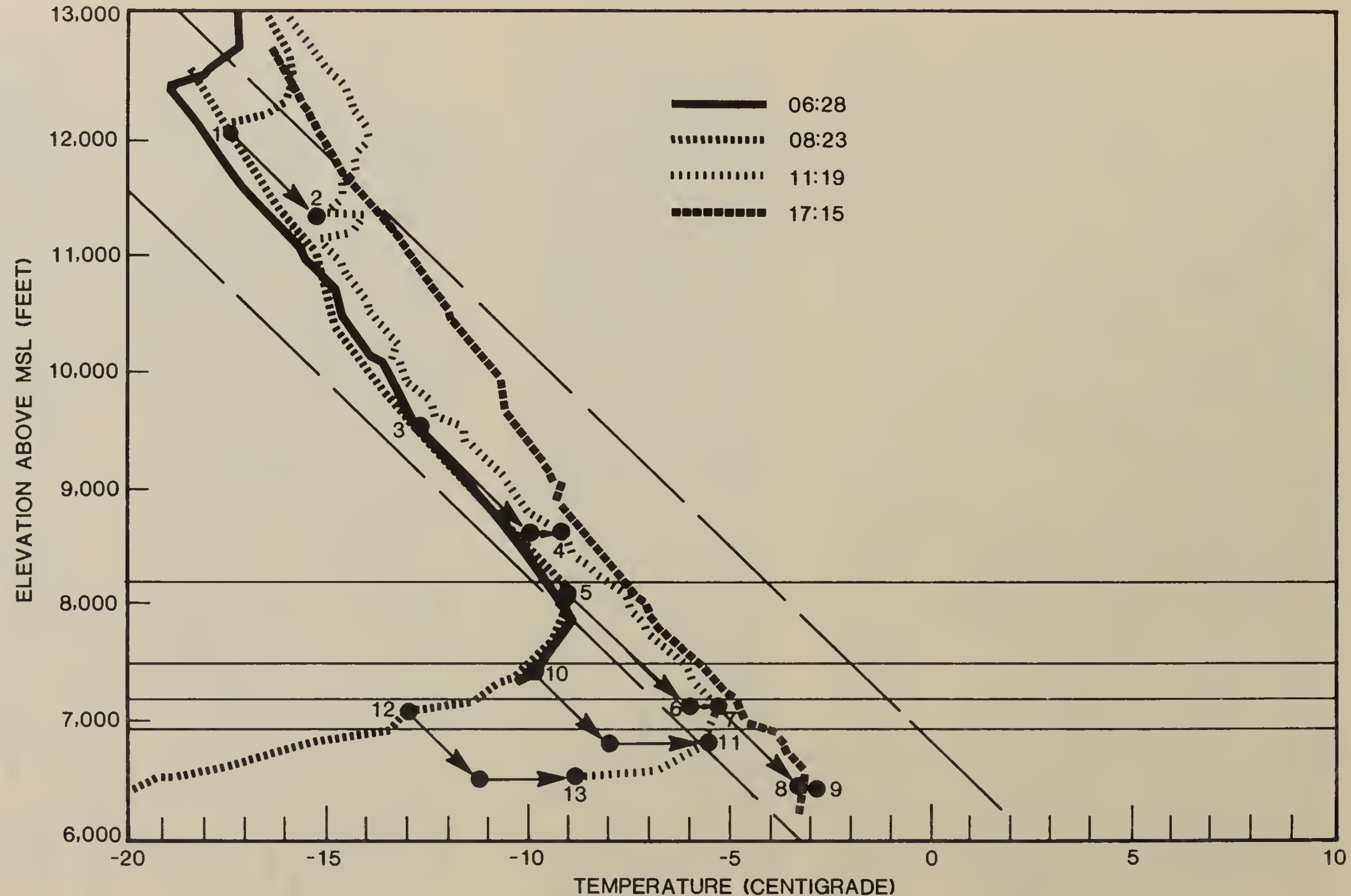


FIGURE 3-10 TEMPERATURE SOUNDINGS MADE ON TRACT C-b AS OBTAINED BY AIRCRAFT ON FEBRUARY 6, 1975

virtually certain that a large stratum of the free atmosphere had subsided during the time between soundings. At its lower boundary the stratum had descended from Point 5 to Point 7. The descent of the top of the stratum appeared to have been adiabatic, since the arrow joining these points was parallel to the adiabats. At the base, however, the warming must be taken as partially adiabatic (that shown by the arrow from Point 5 to Point 6) and partially (diabatic) solar heating (that between Points 6 and 7). Continued adiabatic descent and solar heating of the air at Point 6 is evident and is shown by Points 7, 8, and 9. Other points within the strata which are assumed to be identifiable in the cold air are traced downward by the arrows from Points 10 to 11, and 12 to 13. (Both adiabatic-descent and solar-heating segments are shown.)

Several highly significant conclusions follow from this analysis. As the near-surface air rises along the slopes due to heating, the vast bulk of cold air in the valley continues to flow out of the valley, subsides, and is warmed adiabatically while doing so. Therefore, only a small part of the cold pool must be heated by solar radiation for the air in the valley to change from a very stable to a neutrally stable condition. The cold air does remain stable; however, while it is subsiding any pollutant which may have been in the air high above the surface at sunrise will descend with little mixing until it is near the surface. It will then spread outward and upward along the slopes and be mixed rapidly throughout the depth of the newly established neutral stratum.

Because of the similarity of the temperature soundings in all four seasons, valley flow should also be quite similar from season to season. Aircraft soundings were not made during inclement weather. Consequently they failed to show what happened in the valley during stormy weather. The same can be said of tethersonde and pibal soundings. It is generally assumed that good mixing will occur throughout the valley during stormy or cloudy weather and good mixing is accompanied by a neutral lapse rate.

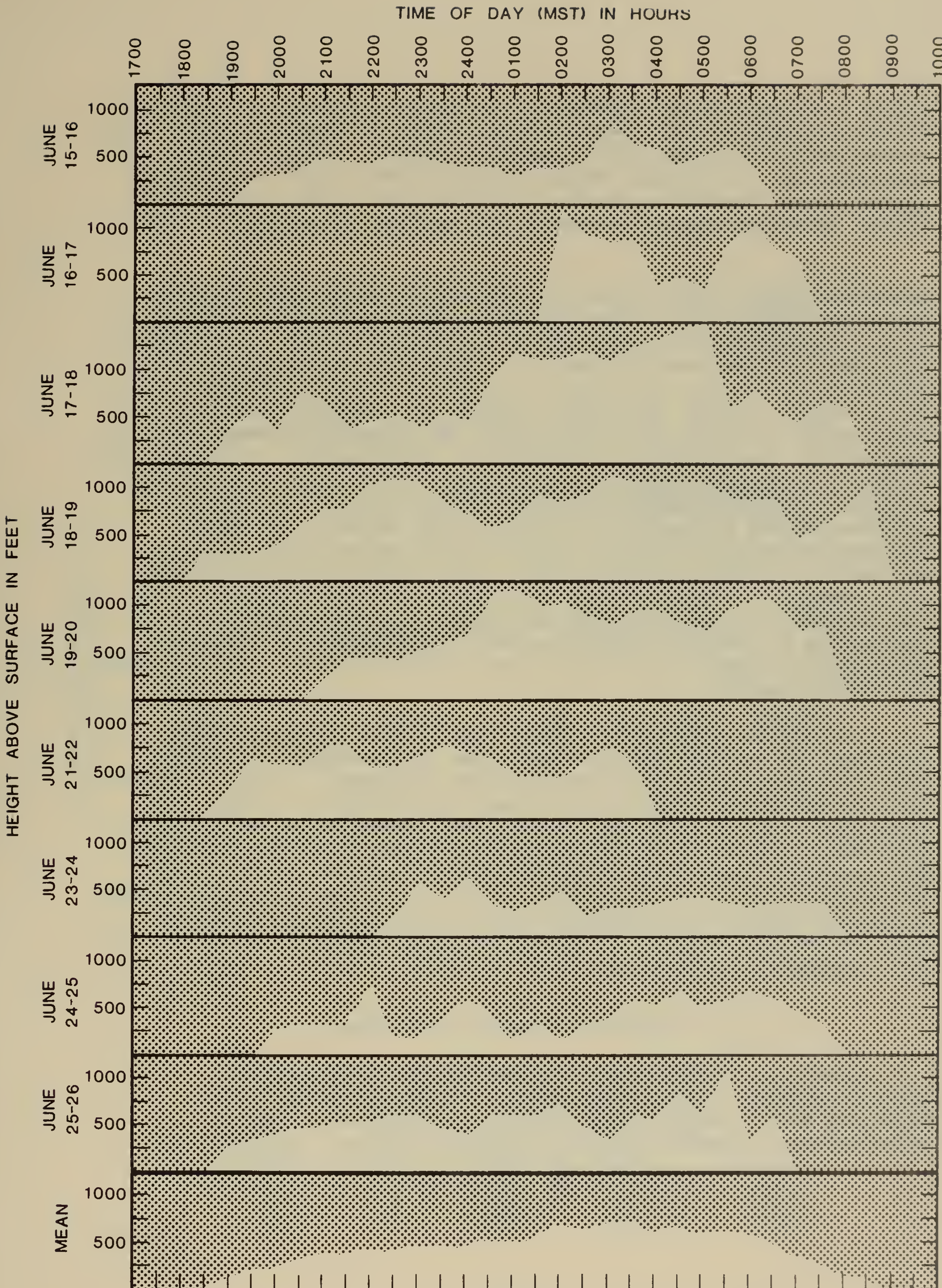
Further insights into vertical temperature profiles are provided by comparisons between the various sounding techniques (meteorological tower, aircraft, acoustic sounders and tethersonde) in the appendix in Section B.1.2.

3.1.2.5.3 Inversion Statistics

The height of the top of the ground-based inversions is important relative to the diffusion of atmospheric pollutants in that it inhibits diffusion a) above its top for stacks below the top, and b) below its top for stacks above its top. Inversions have been studied by all four of the previously mentioned techniques. Typical inversion-top time histories obtained from the sounder at Station 023 are shown on Figure 3-11 for dates corresponding to the tethersonde test (and for which the sounder was operational). For this case, the mean inversion formed at 1830 MST at the surface, rose to a maximum (top) height of 750 ft. at 0330 MST, then decreased in height and broke up at 0900 MST. More complete statistics on a monthly basis for Stations 023, 021, and 020 are presented in the appendix, Section B.1.2.

Measurements were obtained at Station 023 on the plateau from December 1974 through October 1976. Inversions occurred on 78 percent of the days on which measurements were made (69 percent of the total days represents instrument "up" time); average inversion duration was 9.5 hours; average height was 723 feet; median time of onset was 2030 hours MST and median time of breakup was 0630 hours MST. Station 021 in Piceance Creek at Rock School was operational from July 1975 through June 1976 (48 percent of the time in as "up" time). Inversions occurred on 82 percent of the days measurements were taken; average inversion duration was 9.8 hours; average height was 1,115 feet; median time of onset was 2030 hours MST and median time of breakup was 0630 hours MST. For the concurrent period of overlapping measurements for Stations 023 and 021, since their installation (July 1975 - June 1976), they compare as follows:

	Station 021	Station 023
Total number of days of measurement ("up" time)	200	256
Total number of days with inversions	178	219
Total number of days with no inversions	22	37
Percent of days of measurement with inversions	79.5	73.4
Total number of inversions	159	188
Mean inversion duration (Hrs.)	9.8	10.2
Mean average inversion height (top) above surface (Ft.)	1,115	565
Mean average inversion height (top) above MSL (Ft.)	7,315	7,545



TYPICAL INVERSION-TOP TIME HISTORIES (STATION 023)

FIGURE 3-11

Tables 3-6a and 3-6b are summaries of inversion statistics by season of the year for the total period of measurement at Stations 023 and 021, respectively. For Station 023, inversion heights averaged 898 feet for mean durations of 9.0 hours during the first year; in the second year, average height lowered to 564 feet and durations increased 10.4 hours. Longest durations occurred in winter and shortest in spring or summer.

For Station 023, as diurnal variations by season for 1975, the probability of an inversion and its expected or mean height are presented on Figure 3-12. It is to be noted that when the probability of an inversion is ≥0.5, an inversion is expected to occur, i.e., expected inversion durations were obtained for segments of the probability-of-occurrence curve ≥0.5. The times of flight of the aircraft which flew in the winter, spring, and summer quarters are indicated by arrows on this figure. In this probability study, the degree of agreement between aircraft and sounder data as "sources" was investigated. It was addressed in detail in Summary Report #6; in essence, it was shown that the best estimate of agreement between sounder and aircraft on the presence of an inversion was 96 percent. For cases where at least one source (aircraft or sounder) indicated there was an inversion, the agreement on inversion height to within ±300 ft. occurred in 75 percent of the cases examined. A related study included in the same reference showed that aircraft flights of 15-days per quarter did not provide adequate information to construct diurnal curves of probability of occurrence, duration, or height of inversion in the context of being "representative" for a total quarter.

Not only are the above "average" type of inversion statistics important, but extreme-duration inversions are important to consider from the standpoint of potential pollution "episodes." Ranked extreme-duration inversions longer than 24 hours are presented on Table 3-7a along with times of onset and breakup, mean inversion height and wind-persistence information (directional persistence, number of hours for this direction, mean speed at this direction, and mean speed over the entire inversion). The longest inversion to date was 43 hours starting on December 19, 1974. The longest wind directional-persistence (26 hours of SSW wind of which 16 were consecutive) occurred with a 37.5 hour inversion on January 14, 1975. See Table 3-7b.

3.1.2.5.4 Atmospheric Stability Assessment

Atmospheric stability has been defined by using Pasquill-Gifford stability classes (Table 3-8). In this arbitrary system, there are seven classes (Class A through Class G) with Class A being the most unstable and Class G the most stable. Stability has

Table 3-6

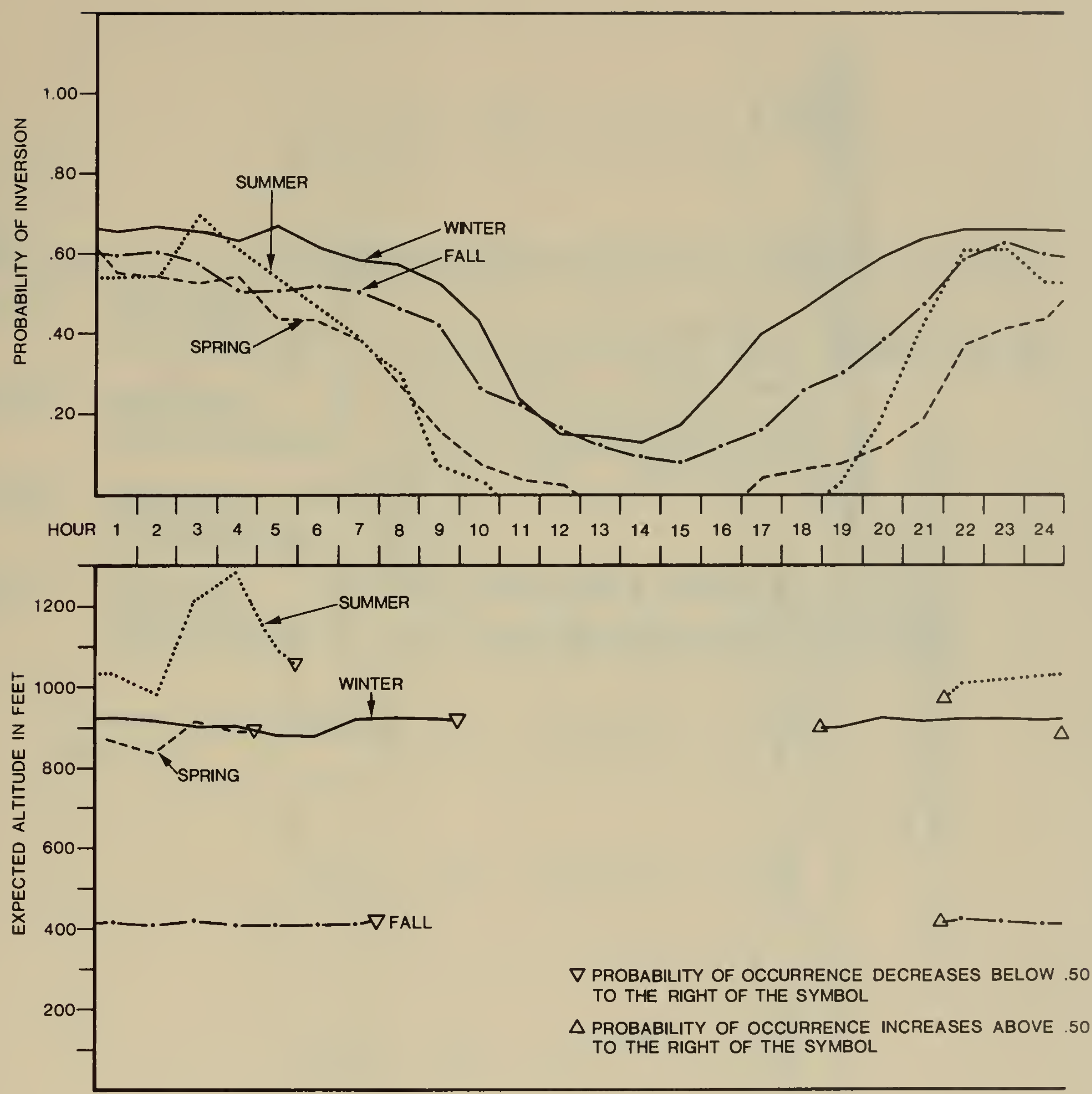
SEASONAL INVERSION STATISTICS
a. Station 023

Season	No. Inversions ÷ No. Days of Measurement	Mean Height of Inversion Top (Feet)	Mean Duration (Hours)	Median Time of Onset (MST)	Median Time of Breakup (MST)
Winter (December '74, January, February '75)	0.82	1087	13.7	18:30	07:00
Spring '75	0.88	1066	5.6	22:30	04:30
Summer '75 (June missing)	0.89	1028	5.0	21:30	02:30
Fall '75	0.71	409	10.8	21:00	08:00
Winter (December '75, January, February '76)	0.67	523	13.5	19:30	07:30
Spring '76	0.81	486	10.1	20:00	07:00
Summer '76 (July missing)	0.73	593	8.2	21:30	06:00
Fall '76 (Partial November)	0.81	654	9.4	20:00	08:00
1st Year	0.81	884	8.8	21:00	06:00
2nd Year	0.74	561	10.3	20:00	07:00
Two Year	0.78	723	9.8	20:30	06:30

Table 3-6

SEASONAL INVERSION STATISTICS
b. Station 021

Season	No. Inversions ÷ No. Days of Measurement	Mean Height of Inversion Top (Feet)	Mean Duration (Hours)	Median Time of Onset (MST)	Median Time of Breakup (MST)
Summer '75 (June missing)	0.95	987	7.7	21:30	07:00
Fall '75 (October missing)	0.75	1487	11.2	20:00	00:30
Winter (December '75, January, February '76)	0.77	1441	12.3	19:00	08:00
Spring '76	0.82	615	7.9	21:00	07:00



DIURNAL VARIATIONS IN THE PROBABILITY OF AN INVERSION AND ITS MEAN HEIGHT BY SEASON OF THE YEAR

FIGURE 3-12

Table 3-7 RANKED LONG-DURATION INVERSIONS GREATER THAN 24 HOURS

a. Without Regard to Atmospheric Stability

DATE	INVERSION DURATION (HOURS)	TIME OF ONSET (MST)	TIME OF BREAKUP (MST)	MEAN HEIGHT OF INVERSION TOP/FT	MAXIMUM WIND PERSISTENCE @ STATION 023 @ 100 FEET			
					DIRECTION	NO. HOURS	MEAN SPEED @ SPEC. DIR. (MPH)	MEAN SPEED OVER INVERSION DURATION (MPH)
12/19-12/21-74	43	17:00	12:00	1547	SSW SW	8 5	9.4 17.8	9.2 9.2
1/20-1/22-76	41 1/2	20:30	14:00	293	SW	4	6.0	1.9
12/8-12/10-74	40 1/2	16:30	09:00	709	W	3	7.0*	3.5*
1/14-1/16-75	37 1/2	17:30	07:00	1425	SSW	26	10.3	8.6
12/18-12/20-75	34	20:00	06:00	422	WNW	3	3.0	1.7
2/13-2/15-75	32 1/2	15:30	00:00	1330	NW SSW S	6 5 5	6.5 13.0 13.8	8.3 8.3 8.3
11/12-11/13-75	32 1/2	05:00	13:30	452	NNE	3	2.3	3.2
1/1-1/2-75	32	02:00	10:00	444	S SW	2 2	2.5 5.0	3.4 3.4
1/19-1/20-76	28 1/2	17:00	21:30	247	WNW	2	2.0	1.8
2/1-2/2-75	24	11:00	11:00	671	SSW	8	12.1	9.1
12/20-12/21-75	24	11:30	11:30	474	SE	5	2.8	1.8

* Partial Data

Table 3-7 RANKED LONG-DURATION INVERSIONS GREATER THAN 24 HOURS

b. With Direction Persistence of 6 or more Hours and at Specified Stability
Station 023

HOUR	12/19-12/21-74, 43 Hrs. Stability Class *	Wind Speed (MPH)	Wind Direction (Sector)	Inversion Altitude (Feet)	1/14-1/16-75, 37 1/2 Hrs. Stability Class	Wind Speed (MPH)	Wind Direction (Sector)	Inversion Altitude (Feet)	2/13-2/15-75, 32 1/2 Hrs. Stability Class	Wind Speed (MPH)	Wind Direction (Sector)	Inversion Altitude (Feet)	2/1-2/2-75, 24 Hrs. Stability Class	Wind Speed (MPH)	Wind Direction (Sector)	Inversion Altitude (Feet)
15																
16									D	10	SSW	295				
17		(1)		722						14	SSW	394				
18		6	NNW	853	E	13	SSW	853		13	SSW	459				
19		5	E	787		5	SSW	1181	E	11	SSW	525				
20		5	SW	656	C	4	SSW	1444	D	17	SSW	787				
21		6	SSW	459	A	8	SSW	1640		18	S	1181				
22		4	S	722	D	10	SSW	1444	E	12	S	1837				
23		3	SSW	1509		20	SSW	1640	D	15	S	2165				
24		7	SSE	1312		16	SSW	1575		14	S	1837				
1		5	S	722	E	15	SSW	1640		10	S	2231				
2		2	SE	787		17	SSW	1509		5	SSE	656				
3		2	SSE	656	D	14	SSW	1509	E	3	SSE	820				
4		2	SW	984	E	17	SSW	1542		4	SE	853				
5		5	SSW	1476		6	SSW	1312		(1)		722				
6		4	S	1378	D	8	SW	1181				1903				
7		6	SSW	1444	E	4	SSW	1378				1969				
8		9	SSW	1444		5	SSW	1116				919				
9		10	SSW	1247	F	8	SSW	1640				984				
10		13	SSW	1476		3	S	1706				984				
11		14	SSW	1772		7	SSW	1805	E	1	N	1280	D	15	SSW	262
12		(1)		2034	E	10	SSW	1772	D	3	N	1772		17	SSW	492
13				1772	D	11	SSW	1969		3	NW	1774		16	SSW	459
14				2165		12	SSW	1608	E	4	NW	1837		16	SSW	361
15				1640		13	SSW	1575	D	9	NNW	1640		12	SSW	623
16				1542	C	15	SSW	1640		7	NW	1509		10	SW	853
17				1575	B	15	SSW	1378		8	NW	1476		10	SSW	722
18		7	SSW	1575	E	13	SSW	1476		8	NW	1772		6	SSW	361
19		9	SSW	1772		3	S	1247	E	9	NW	2133	E	5	SSW	197
20		7	SSW	1772	D	2	SSW	1378		8	WNW	1969		3	SSE	262
21		6	SSE	1575	A	1	ESE	1247		7	WNW	1476	F	3	SSE	394
22		10	SSE	1706	E	5	SSW	1837		5	WNW	1476		3	E	525
23		10	SW	1444		2	E	1050		3	W	1673		4	SSE	787
24		6	S	1378	D	5	S	1050		4	W	984	E	5	S	787
1		7	SW	1444		(1)		1148						6	SSE	1116
2		7	S	1640	E	6	SSW	1509						7	SSE	984
3		8	S	1411		(1)		1444					F	8	SSE	919
4		12	SW	1476	F	3	ESE	853					E	9	SE	1247
5		16	WSW	1542	D	3	SSE	1247					F	8	SE	787
6		20	WSW	1706	E	4	SSW	1378					E	8	SE	1116
7		20	SW	2494		7	SSW	1509					D	13	SSE	853
8		21	SW	3281									E	15	SSE	328
9		18	SW	3281										9	SE	394
10		17	SW	2953										4	SSE	1050
11		13	SW	2428												
12		19	WSW	1640												

* No stability class data available during the month of December, 1974.

(1) Missing data.

Table 3-8 DETERMINATION OF PASQUILL-GIFFORD STABILITY CLASSES FROM VARIOUS SOURCES

Pasquill-Gifford Stability Class	Slope of the Temperature-Altitude Curve dT/dz (°C/100m)	Standard Deviations of Wind Direction Components: Horizontal σ_θ (Deg.)	Vertical σ_ϕ (Deg.)
A	< -1.9	> 23	
B	-1.9 to -1.7	18 to 23	> 15
C	-1.7 to -1.5	13 to 18	9 to 15
D	-1.5 to -0.5	8 to 13	6 to 9
E	-0.5 to 1.5	4 to 8	2 to 6
F	1.5 to 4.0	2 to 4	0 to 2
G	> 4.0	< 2	

been determined by the following techniques:

1) Tower incremental temperatures (ΔT) (200'-30')
2) Tower Horizontal Wind Dir. Std. Deviation (σ_θ) (200')
3) Tower Vertical Wind Dir. Std. Deviation (σ_ϕ) (200')
4) Solar Radiation and Wind Speed (Daytime Only) (Integrated)
5) Aircraft Temperature Profiles (600', 1000')
6) Tethersonde ΔT (200'-30')
7) Tethersonde Horizontal Wind Dir. Std. Deviation (σ_θ) (600')

Tower data, particularly applicable to low level plume releases, were the only continuous source of these data. Data applicable to high level sources (equivalent to plumes at $\geq$600') were obtained from short term studies with the exception of the pyranometer which provided data only in the daytime. All ΔT data were corrected for wind speed by the EPA - recommended technique shown on Table 3-9; the tower 30'-level wind speeds were used.

Long term stability assessment has been obtained from the meteorological tower and (separately) from the pyranometer as indicated on Table 3-10. The selective stippled regions on this table indicate unstable regions occurring in the middle of the day (A, B, C) and the stable regions (E, F) occurring in the evening and early morning; whereas the clear region depicts neutral stability (D). Stability class frequency distributions are presented on Table 3-11. Class D (neutral) occurred most frequently on the average; Class A was least frequent the first year, C in the second. Highest percent of stable Class F's occurred in late summer to early fall (July - October). During the daytime there was good agreement (within one stability class) between tower ΔT and pyranometer.

Table 3-12 presents the average stability estimates at 600-foot and 1000-foot elevations for four (15-day) quarters of aircraft data, as adjusted for wind speeds. Wind speeds were obtained from pibal releases on the same dates as the aircraft flights. Elevations of 600 and 1000-feet were considered "representative" of high altitude releases for diffusion modeling purposes. Table 3-13 compares typical tower and pyranometer results with aircraft for the spring quarter (April 1975 aircraft flights). For the April example, only the tower indicated both A and F stability; the aircraft yielded all D's and E's; for the 11:00 a.m. MST flight time, the tower averaged C stability as did the pyranometer, whereas the aircraft averaged D. Thus from aircraft data at a 1000-foot height the

Table 3-9 WIND SPEED ADJUSTMENTS* TO PASQUILL - GIFFORD STABILITY CLASSES OBTAINED FROM METEOROLOGICAL ΔT DATA

STABILITY FROM ΔT	WIND SPEED (WS) (MPH)	"ADJUSTED STABILITY"
A	WS<4.47	A
	4.47≤WS<11.18	B
	11.18≤WS≤13.42	C
	WS>13.42	D
B	WS<11.18	B
	11.18≤WS≤13.42	C
	WS>13.42	D
C	WS≤13.42	C
	WS>13.42	D
D	ALL SPEEDS	D
E	WS≤11.18	E
	WS>11.18	D
F	WS<6.71	F
	6.71≤WS≤11.18	E
	WS>11.18	D

*Source: EPA

Table 3-10 AVERAGE HOURLY STABILITY CLASSES

SOURCE: TEMPERATURE DIFFERENCES BETWEEN 200 FT AND 30 FT ON THE MET TOWER
(Adjusted for Wind Speed)

Month	Hour 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Average
Nov.*																									
Dec.*																									
Jan.75	D	D	D	D	D	D	D	D	E	E	E	E	D	D	D	D	D	D	D	E	D	D	D	D	D
Feb.	E	E	E	E	E	E	E	E	E	D	D	C	D	C	C	D	D	E	E	E	E	E	E	E	E
Mar.	D	D	D	D	D	D	D	D	C	C	C	C	C	C	D	D	C	C	D	D	D	D	D	D	D
Apr.	D	D	D	D	D	D	D	B	C	C	C	C	C	C	C	C	C	C	C	D	D	D	D	D	C
May	D	D	D	D	D	D	D	B	B	B	C	C	C	C	C	C	C	C	C	C	D	D	D	D	C
June	E	E	E	E	F	E	D	B	B	B	B	C	C	B	C	C	C	C	C	C	D	D	E	E	D
July	-	-	-	MISSING DATA					-	-	-	B	B	B	B	B	B	C	-	-	-	-	-	-	B
Aug.	F	F	F	F	F	E	E	E	C	B	C	C	C	C	C	C	C	C	D	E	E	F	E	E	D
Sept.	F	E	E	F	F	F	F	E	B	B	B	B	B	C	B	B	C	B	E	E	E	F	F	F	D
Oct.	E	E	E	E	E	E	E	E	C	B	B	C	B	C	C	C	B	C	D	D	E	E	E	E	D
Nov.	D	D	D	D	D	D	D	D	C	B	B	B	C	B	B	B	B	C	D	D	D	D	D	D	D
Dec.	D	D	D	D	D	D	D	D	C	C	B	B	B	B	B	B	B	C	C	C	D	D	D	D	C
Jan.76	D	D	D	D	D	D	D	D	D	C	B	B	B	B	B	B	B	B	C	C	D	D	D	D	D
Feb.	D	D	D	D	D	D	D	D	C	C	C	C	C	C	C	C	B	B	C	D	D	D	D	D	C
Mar.	D	D	D	D	D	D	D	C	C	C	B	B	C	C	C	B	C	C	B	C	C	C	C	C	C
Apr.	D	D	D	D	D	D	D	B	B	C	C	C	C	C	C	C	C	C	C	D	D	D	D	D	C
May	E	E	E	E	E	E	D	B	B	B	B	B	B	B	B	B	B	B	C	D	D	E	E	E	C
June	E	E	E	E	E	E	E	C	C	C	C	C	C	C	C	C	C	C	C	D	E	E	E	E	D
July	E	E	E	E	E	F	E	B	B	B	B	B	B	C	B	B	B	B	B	D	E	E	E	E	D
Aug.	E	E	E	E	E	E	E	C	B	B	C	C	C	C	C	C	C	C	C	E	E	E	E	E	C
Sept.	E	E	E	E	E	E	E	D	B	B	B	B	B	B	B	B	B	B	D	D	D	E	E	E	D
Oct.	E	E	E	E	E	E	E	B	B	B	B	B	B	B	B	B	B	C	D	E	E	E	E	E	D

SOURCE: PYRANOMETER (DAYLIGHT ONLY)

Month	Hour 6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Nov.															
Dec.															
Jan.75					C	C	C	C	C	C	C				
Feb.					C	C	C	C	C	C	C				
Mar.					C	D	D	D	D	D	D				
Apr.					C	C	C	C	D	D	D				
May		C	C	C	C	C	C	C	C	D	D	D	D	D	
June		C	C	C	C	C	C	C	D	D	D	D	D	D	
July		C	C	C	B	B	B	C	C	C	C	C	C	D	
Aug.		C	C	C	C	C	C	C	C	C	D	D	D	D	
Sept.		C	C	C	C	C	C	C	C	C	C	C	D	D	
Oct.		C	C	C	C	C	C	C	C	C	C	D	D		
Nov.			C	C	C	C	C	C	C	C	D	D			
Dec.			C	C	C	C	C	C	C	C	D	D			
Jan.76			C	C	C	C	C	C	C	C	D	D			
Feb.			C	C	C	C	C	C	C	C	C	D	D		
Mar.		C	C	C	C	C	C	C	C	C	C	D	D	D	
Apr.	C	C	C	C	C	C	C	C	C	C	D	D	D	D	
May	C	C	C	C	C	C	C	C	C	C	C	C	C	D	
June	C	C	C	C	C	C	C	C	C	C	D	D	D	D	D
July	C	C	C	C	B	B	B	C	C	C	C	C	C	D	D
Aug.	D	C	C	C	C	C	C	C	C	D	D	C	D	D	
Sept.		C	C	C	C	C	C	C	C	C	C	D	D	D	
Oct.		C	C	C	C	C	C	C	C	C	C	D	D		

KEY:

Unstable Cases

D Neutral

Stable

*Data are suspect

Table 3-11 METEOROLOGICAL SUMMARY: STABILITY CLASS FREQUENCIES (%)

Source: Met. Tower[1] (30' to 200')

Pasquill-Gifford Stability Class	dT/dz Range[1] for this Stability Class (°C/100m)	1974 Nov.[2]	1974 Dec.[2]	1975 Jan.	Feb.	Mar.	Apr.	May	June	July[3]	Aug.	Sept.	Oct.	Annual Mean
A	<-1.9			8.3	1.0	1.1	12.0	7.4	8.6	0.0	2.4	5.8	8.1	6.1[4]
B	-1.9 to -1.7			5.5	4.4	10.3	23.5	30.6	25.6	85.7	19.3	23.4	20.6	18.1
C	-1.7 to -1.5			4.1	2.4	16.3	6.9	9.3	6.9	14.3	6.1	5.0	5.7	7.0
D	-1.5 to -0.5			33.0	43.4	60.9	36.3	30.0	27.0	0.0	25.8	13.4	28.3	33.1
E	-0.5 to +1.5			33.3	36.8	11.4	18.1	12.1	18.0	0.0	17.3	24.4	18.6	21.1
F	>1.5			15.8	12.0	0.0	3.2	10.6	13.9	0.0	29.1	28.0	18.7	14.6
Total Percentage				100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Pasquill-Gifford Stability Class	dT/dz Range[1] for this Stability Class (°C/100m)	1975 Nov.	1975 Dec.	1976 Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.		Annual Mean
A	<-1.9	15.6	18.8	24.9	13.8	19.4	9.5	17.5	4.6	10.3	7.4	13.1	13.6	14.0
B	-1.9 to -1.7	19.7	20.7	21.3	22.1	27.0	21.7	26.3	17.4	30.5	18.4	25.5	20.6	22.6
C	-1.7 to -1.5	6.9	7.4	5.6	7.7	7.9	9.7	6.0	10.0	5.6	6.7	6.1	5.6	7.1
D	-1.5 to -0.5	23.7	21.5	16.6	35.7	28.7	35.2	21.0	32.7	14.1	27.6	17.5	17.9	24.4
E	-0.5 to +1.5	22.9	23.5	21.0	13.8	15.6	17.0	15.6	17.6	19.5	23.0	20.7	21.2	19.3
F	>1.5	11.2	8.1	10.6	6.9	1.4	6.9	13.6	17.6	20.0	16.9	17.1	21.1	12.6
Total Percentage		100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

[1]Adjusted for wind speed
[2]Data are suspect and, therefore, not included
[3]Partial data
[4]Averaged from January-October, excluding July

Table 3-12
TOWER - AIRCRAFT STABILITY CLASS COMPARISON

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	
FALL					(1)			-			-						-								Tower (average)
WINTER					E			E			D						D								based on inclu-
SPRING					E			B			C						C								sive dates of
SUMMER					(2)			-			-						-								aircraft data)
FALL					E			E			D						D								
WINTER					D			D			D						D								600'
SPRING					E			D			D						D								aircraft data
SUMMER					D			D			D						D								
FALL					D			D			D						D								
WINTER					D			D			D						D								1000'
SPRING					D			D			D						D								aircraft data
SUMMER					E			D			D						D								

(1) Tower data questionable (2) Tower data incomplete

Span of Aircraft Flights

Fall (10/1/74 - 10/15/74)

WINTER (1/20/75 - 2/9/75)

SPRING (4/14/75 - 5/1/75)

SUMMER (7/12/75 - 7/26/75)

Table 3-13

TYPICAL COMPARISON OF STABILITY CLASSES
FOR SPRING 1975 FLIGHT SPAN

	Stability Class @																			
	0500 MST					0800 MST					1100 MST					1700 MST				
Date	(1)	(2)	(3)	(4)	(5)	(1)	(2)	(3)	(4)	(5)	(1)	(2)	(3)	(4)	(5)	(1)	(2)	(3)	(4)	(5)
4/14/75	D	E		D	D	C	B		D	D	D	D	D	D	D	D	B		D	D
15	D	E		D	D	D	D		D	D	D	D	D	D	D	D	D			
16	D	D		D	D	D	C		D	D	D	D	D	D	D	D	D			
17																				
18											B	B	D	D	D	C	B		D	D
19	D	D		E	D	A	A		D	D	B	B	C	D	D	C	C		D	D
20	D	D		E	D	A	A		D	D	-	-	-	D	D	B	B		D	D
21	E	E		E	E	A	A		E	D	-	-	-			D	D		E	D
22	D	E		D	D	D	D		D	D	D	D	D	D	D	D	D		D	D
23	F	F		E	D	D	D		D	D	D	D	D	D	D	D	D		D	D
24	D	D		E	E	A	A		D	D	B	B	B	D	D	D	D		D	D
25	D	D		D	D	D	D			D	D	D	D			D	D			
26																				
27																				
28	D	D		E	D	A	A		E	D	B	A	B	D	D	C	B			
29	A	A		E	D	A	A		D	D	B	A	B	E	D	B	B			
30	D	D		E	D	A	A		D	D	A	A	B	D	D	B	B		D	D
5/1/75	E	E	-	E	E	A	A	B	D	D	C	B	C	D	D	B	B	D	D	
Average	D	D		E	D	B	B		D	D	C	C	C	D	D	C	C		D	D

Note a) Entries (left to right) are

(1) Meteorological Tower (30' to 200') corrected for wind speed (200')
(2) Meteorological Tower (30' to 200') corrected for wind speed (30')
(3) Pyranometer (daylight hours only)
(4) Aircraft T vs h slope @600' corrected for wind speed
(5) Aircraft T vs h slope @1000' corrected for wind speed

stability class indicated on all flights for all quarters was never anything other than D or E; only one C and one F were obtained at 600 feet. Figure 3-12 depicts mean altitude of the top of the inversion layer from sounder data for which the probability of an inversion is greater than 0.5 (i.e., that portion for which an inversion is present on an "expected" basis). This corroborates the expectation that F stability is not to be expected from aircraft data, except during summer, and then only if stability slopes are estimated below 1000-foot altitude. This is because inversion tops exceed 1000-feet only during the summer and only then for the 5:00 a.m. flights; no inversions exist on an expectation basis at other flight times. It is also expected that better mixing occurs in winter. Restated, the tower should and does indicate a higher percentage of F stability than does the aircraft (at 600 feet and 1000 feet). Acoustic sounder and aircraft provide corroborative data on the low frequency of stable lapse rates (categories) above 1000 ft.

Still another comparison of stability from all the seven previously mentioned techniques is presented on Table 3-14 for the period covering the 10-day tethersonde test. Referring also to Figure 3-11 showing the mean height of the inversion as a time history, results appear consistent. That is, the tower ΔT and the tethersonde ΔT in the table indicated E and F for heights below the inversion top from 2000 MST until after 0700 MST. The figure indicates the inversion height was above 200' between 1910 MST and 0740 MST. Wind direction standard deviation techniques from the tethersonde indicated C's and D's throughout the early morning suggesting that the peak inversion height might be below the peak of 750' indicated by the sounder on the figure down to slightly below 600'.

3.1.2.5.5 Conclusions

In summary, the C-b Tract and surrounding areas are subject to very wide temperature extremes. Yearly ranges from -51^{0}F to +98^{0}F have been observed. Lowest temperatures were observed at Rock School (Station 021) in Piceance Creek valley. Radiational cooling in the valleys triggers drainage flows at night causing these low temperatures. Intense ground-based inversions have formed on approximately 82 percent of the nights in Piceance Creek valley and 75 percent of the nights on the Tract. They form in early-to-late evenings and usually dissipate from early-to-mid mornings. One extreme duration inversion lasted 43 hours. Atmospheric-stability measurements provide important inputs to air diffusion models used for the study of transport of atmospheric-pollutants. The meteorological tower has provided adequate assessment of stability to heights of 200 feet above the surface. Aircraft, tethersonde, and pyranometer measurements have provided selective, not continuous, data to higher elevations; the acoustic sounder has provided continuous data on inversion heights. Ground-based inversions produced

TABLE 3-14 MEAN HOURLY STABILITY CLASS DETERMINATIONS FROM VARIOUS METHODS DURING THE TETHERSONDE TEST (June 1976)

		HOUR																							
METHOD	ALTITUDE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Tower ΔT Level II	30'-200'	E	E	E	E	E	E	E	B	B	B	B	C	C	C	C	C	C	C	C	D	E	E	E	E
Tethersonde ΔT (Both Stations)	30'-200'			F	E	E	E	E	D	D	C		D	D		C									
Tethersonde ΔT (Station 023)	30'-200'			E	E	E	E	E	E	C	C		D												
Pyranometer	Integrated						C	C	C	C	C	C	C	C	C	C	C	D	D	D	D				
Tethersonde ΔWD (Both Stations)	600'			C	C	C	C	B	D	B	B		A	A		A									
Tethersonde ΔWD (Station 023)	600'				C	D	A	B	D	A	B		A												
Tower ΔWD	200'				D	C	B	C	B	A	B		B												
Tower Bivane Horizontal ΔWD	200'				D	D	B	C	B	A	B		B												
Tower Bivane Vertical ΔWD	200'				F	F	F	F	E	E	F		F												

stable atmospheric conditions (Class F) near the surface whereas conditions above the top of the inversion may vary from neutral (D) to unstable (Class A). As a surface-based inversion dissipates, the air near the surface becomes progressively warmer and more unstable so that by afternoons it is usually unstable. Statistically, Class D has been predominant both years (24 to 33 percent) with unstable A occurring 6 to 14 percent of the time and stable F occurring 13 to 15 percent of the time from tower data. Frequency of stable F cases decreases with increasing elevation.

3.1.3 Other Meteorological Parameters

This section discusses solar radiation, relative humidity, and barometric pressure. All three are measured as part of the air quality - meteorology network previously described in Section 2.5.1. Solar radiation is measured only at Station 023. Relative humidity is measured at all five trailer locations and at four levels on the meteorological tower. Barometric pressure is measured at trailers 023 and 024. Associated instrumentation, methodology, and quality assurance are presented in the appendix, Section A.1.1. It is to be noted that precipitation is discussed in Volume II for the sake of completeness.

3.1.3.1 Solar Radiation

Solar radiation was monitored at Station 023 during the baseline period covering November 1974 to October 1976. Data are presented in the appendix in Section B.1.3 in total langleys received and have been modified to include radiation received during downtime (instrument calibration, computer downtime, etc.).

The Tract C-b region received less solar radiation during the November 1974 through October 1975 period than it did during the November 1975 through October 1976 period. A total of 126,051 langleys were recorded during the first twelve months of the baseline period, whereas a total of 137,021 langleys were recorded during the second twelve-month period. This represents a net difference of about 8 percent for the annual comparison and corresponds roughly with data from the Grand Junction National Weather Service for the same period.

On a seasonal basis, the following comparisons can be made. The winter of 1974-1975 (December, January, February) received the least solar radiation (15,201 langleys). The summer of 1976 (June, July, August) received the highest solar radiation total with 51,942 langleys recorded. The winter of 1974-1975 received 17 percent less radiation than did the winter of 1975-1976. The spring of 1975 received 11 percent less radiation than did the spring of 1976 and the summer of 1975 received 7 percent less

radiation than did the summer of 1976. September and October of 1975 received 3.5 percent higher solar radiation than during the same period in 1976. These percentages illustrate a trend of cloudy weather during the initial months of the baseline period, becoming more sunny toward the end of the period. Precipitation and relative humidity statistics for the Tract C-b region further support this trend.

Cloudiness was especially prevalent during the first three months of the baseline period. The daily averages of insolation recorded during this period (Figures 3-13 and 3-14) ranged from approximately 53 percent to 63 percent of the normal daily averages (using National Weather Service data) for the corresponding months at Grand Junction, Colorado.

Another very cloudy period occurred during November and December of 1975, when the daily averages for these two months were 70 percent and 71 percent, respectively, of the predetermined normal totals for Grand Junction. Both the November 1974 - January 1975 and November 1975 - December 1975 periods of below normal insolation can be attributed to the configuration of the upper-level flow. The polar-front jet stream was suppressed southward during those periods, such that the mean position of the jet stream was through the Intermountain Region. This allowed low pressure systems at the surface and aloft to track very near the Tract C-b region, thereby bringing positive vorticity advection and cloudiness to the area. Moreover, the mean long wave trough was situated over the Intermountain Region during a large portion of these two periods. This trough orientation allowed many polar maritime cold fronts and upper-level vortices, which are normally moist, to pass through the Tract C-b region, thereby augmenting the cloud cover and precipitation.

January, February, and March of 1976 received 88, 86, and 90 percent, respectively, of the average monthly insolation for Grand Junction. This was the longest consecutive period during which insolation data from the Tract C-b closely approximated the Grand Junction NWS insolation data. March 1976, with the 90 percent figure, was the sunniest month during the monitoring period (on a percentage basis). Strong upper-level ridging affected the Intermountain Region during this entire January-March period.

January, June, and October of 1976 recorded 88 percent of the average monthly insolation for the corresponding months at Grand Junction, thereby becoming the second most sunny months. A large ridge both at the surface and aloft over the Intermountain Region, acting as a block for any maritime polar fronts to move into the Tract C-b region, was responsible for most of the synoptic-scale sunny weather received in western Colorado during any season. Of course, because of the higher elevation of the C-b region when compared to Grand Junction, slightly more orographically induced cloudiness can be expected, lowering insolation totals at the Tract C-b somewhat.

In summary, the largest seasonal insolation totals were received during the summer and the smallest seasonal insolation totals were received during the winter, as would be expected because of solar elevation considerations. The totals received during the March-April-May

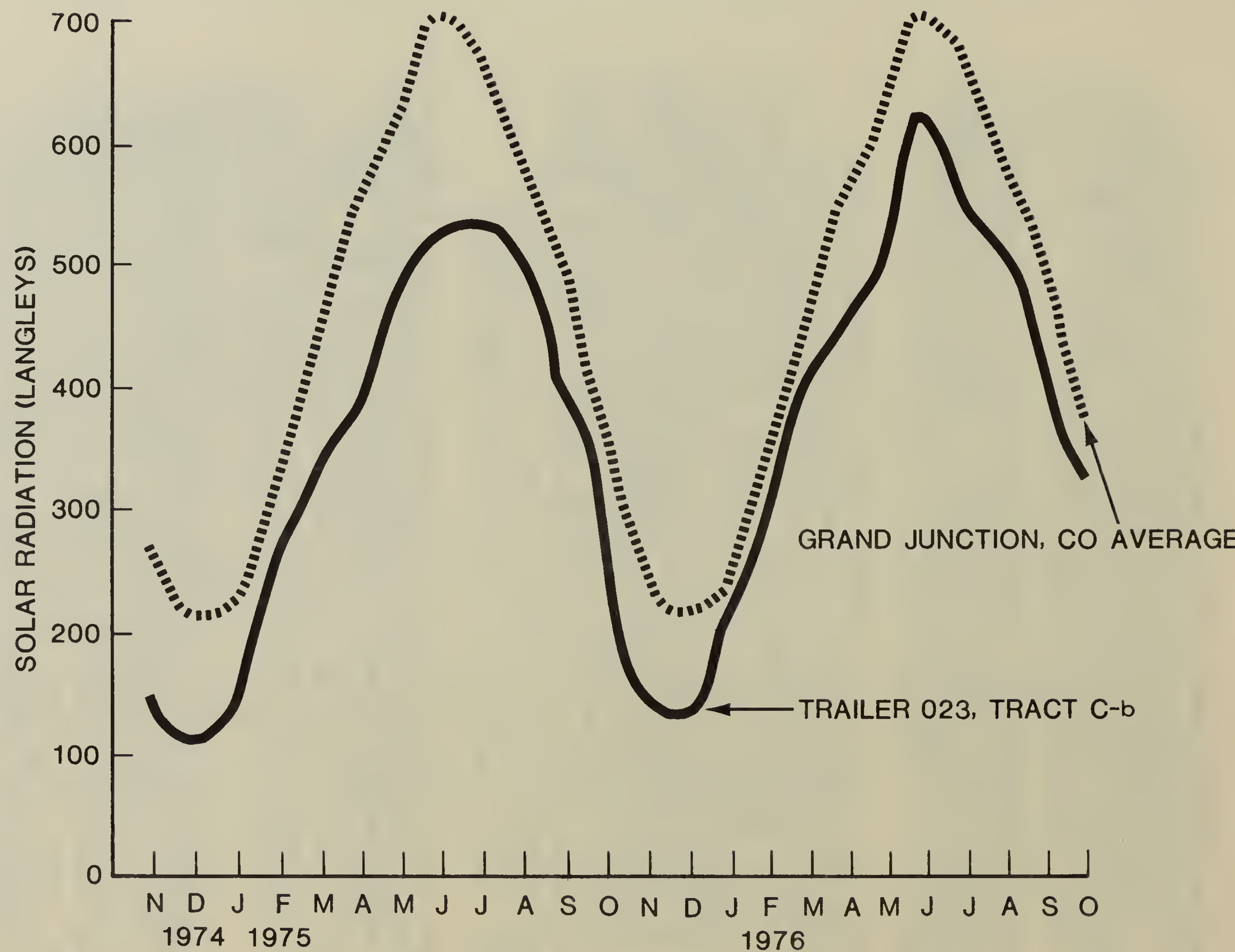
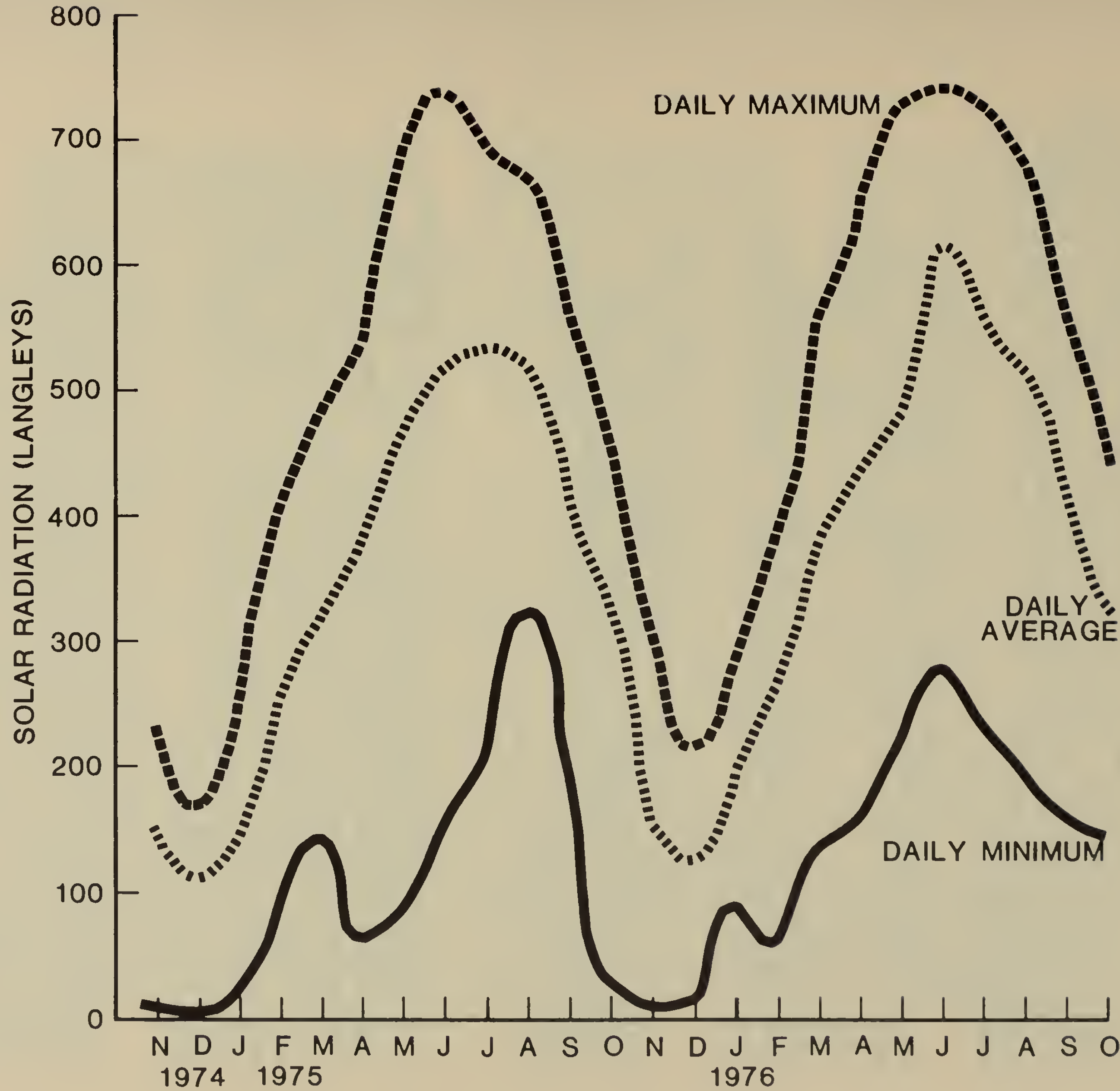


FIGURE 3-13 SEASONAL VARIATION OF DAILY AVERAGE SOLAR RADIATION



SEASONAL VARIATION IN DAILY EXTREMA AND AVERAGE SOLAR RADIATION

FIGURE 3-14

periods were nearly equal to those received during the August-September-October periods because of similar solar elevation patterns and progressions. On a month-by-month basis, insolation totals were larger throughout the November 1975 - July 1976 period than during the November 1974 - July 1975 period. Insolation totals were more uniform during August, September, and October.

The greatest monthly insolation total received during the monitoring period was 18,689 langleys in June of 1976 (a daily average of 623 langleys). The lowest monthly insolation total was 3500 langleys in December of 1974 (a daily average of 112.9 langleys). The highest daily insolation total recorded during the two-year monitoring period was 741 langleys on June 21, 1976 (the summer solstice) while the smallest daily total recorded during the two years of monitoring was 0 langleys on December 7, 1974.

The total solar radiation recorded during the two-year period was 263,072 langleys. This corresponds to a daily average of 359.9 langleys. On a monthly basis, the lowest insolation totals were received during December, while the greatest solar radiation totals occurred during June (in 1976) or July (in 1975).

3.1.3.2 Relative Humidity

Relative humidity, which relates the amount of water vapor in the air to the amount of water vapor that the air can hold (saturation) at that temperature and pressure, showed a definite seasonal variation during the November 1974 to October 1976 period of record. This seasonal relative humidity variational pattern was primarily a function of temperature. That is, when temperatures were highest, relative humidities were lowest, and vice versa. In terms of the actual water vapor content of the air, however, the average dew points were highest during the warm summer months and lowest during the winter.

During the summer months, most cloudiness was orographic and diurnal in nature (occurring mostly during the afternoon), thereby allowing a significant difference between the temperature and dew point (dew point depression) during most of the day. The only exception to this pattern occurred when late afternoon and evening showers and thundershowers developed in the region. During the winter months synoptic-scale systems dominated the weather, resulting in more cloudiness on the average throughout the day. This persistent cloudiness, combined with shorter daytime periods, caused the diurnal temperature ranges to be smaller. As a result, average relative humidities were highest during the winter months, since the average dewpoint depressions were smaller throughout the period.

Throughout the monitoring period, the stations in the Piceance Creek valley (Stations 020, 021, and 022) had average relative humidities that were slightly higher than those recorded on the plateau (the meteorological tower and Station 024). This difference between locations is attributable primarily to the fact that higher average temperatures occurred on the plateau during the period because of the lack of a pronounced katabatic influence during the night at the higher elevations. The greatest difference in average relative humidities between the valley and plateau sites occurred during the winter months, although significant differences in relative humidities also occurred during the warm summer months.

Monthly figures and data tables (Appendix B.1.3) show that the daily average relative humidities demonstrated a considerable amount of variability on a month-by-month basis. That is, the extrema of the daily average relative humidity values for any given month normally had a variation of at least 60 percent. Dry periods, when daily average relative humidities did not exceed 40 percent, were much more common than were very humid periods, particularly during the summer and autumn months when persistent upper-level ridging dominated the region. The dry periods normally lasted for at least four or five days, while the very humid periods (during which precipitation normally occurred) were usually limited to two or three days in duration.

Comparing the relative humidities from the first year to those of the second, little difference was apparent on a month-by-month basis. June and July of 1975 were generally more humid than June and July of 1976. Likewise, August, September, and October of 1976 were more humid than those corresponding months of 1975. The only anomalous relative humidity behavior during the August through October period was the slight decrease in the monthly average relative humidity which occurred from September to October 1976. During the August through October 1975 monitoring period, the monthly average relative humidities increased steadily throughout the region on a month-to-month basis. Moreover, the range of daily average extrema during October 1976 was much less than that of October 1975. The lack of precipitation in the region during October 1976 was responsible for this non-variability (i.e., little day-to-day change in the upper-level ridging during October 1976).

In summary, a basic trend did exist in the relative humidity and moisture content of the air in the region during the two-year period. Relative humidities generally reached their lowest values during the summer months because of the warm temperatures that prevailed. Beginning in September, monthly average relative humidities increased steadily throughout the autumn months, reaching their maximum monthly average values during December.

Monthly average relative humidities then decreased monotonically during the late winter, spring, and early summer months, reaching minimum values during July or August. Temperature was the controlling factor in these relative humidity trends, since the moisture content of the air (measured in dew point temperature) was actually highest during the summer, when the daily average relative humidities were lowest.

3.1.3.3 Barometric Pressure

The utility of barometric pressure is straight forward - when readings are low, they are indicative of adverse weather conditions; when readings are high, they are synonymous with fair weather.

During the two-year monitoring period extending from January 1975 through October 1976, Station 023 had an average measured station pressure of 788.9 millibars. Station 024 had an average station pressure of 793.5 millibars during the period extending from May 1975 through October 1976. Station 024 had the higher average pressure because of its lower elevation.

On a monthly basis the maximum average station pressure occurred during September of both years at both Stations 023 and 024 (Figure 3-15). The September average for the baseline period was 793.2 millibars at Station 023 and 796.7 millibars at Station 024. The cause of these relatively high pressures was the absence of cyclonic influences and dominance of upper-level and surface ridging in the region during the late summer and early fall. The minimum monthly average station pressure occurred during March at both Stations 023 and 024. The March average was 783.7 millibars at Station 023 and 788.4 millibars at Station 024. This March minimum was due to the high frequency of low pressure systems which tracked directly through the region during the late winter and early spring.

The conclusion is that barometric pressure readings at Stations 023 and 024 correlated very well with the overall synoptic pressure patterns. That is when high pressure systems invaded the area high pressure was observed, similarly with low pressure. Although this was expected it verifies that there are no unusual pressure conditions occurring in the C-b region (at least during the two-year baseline period). Barometric pressure on Tract C-b is directly proportional to the synoptic weather pattern influencing the area.

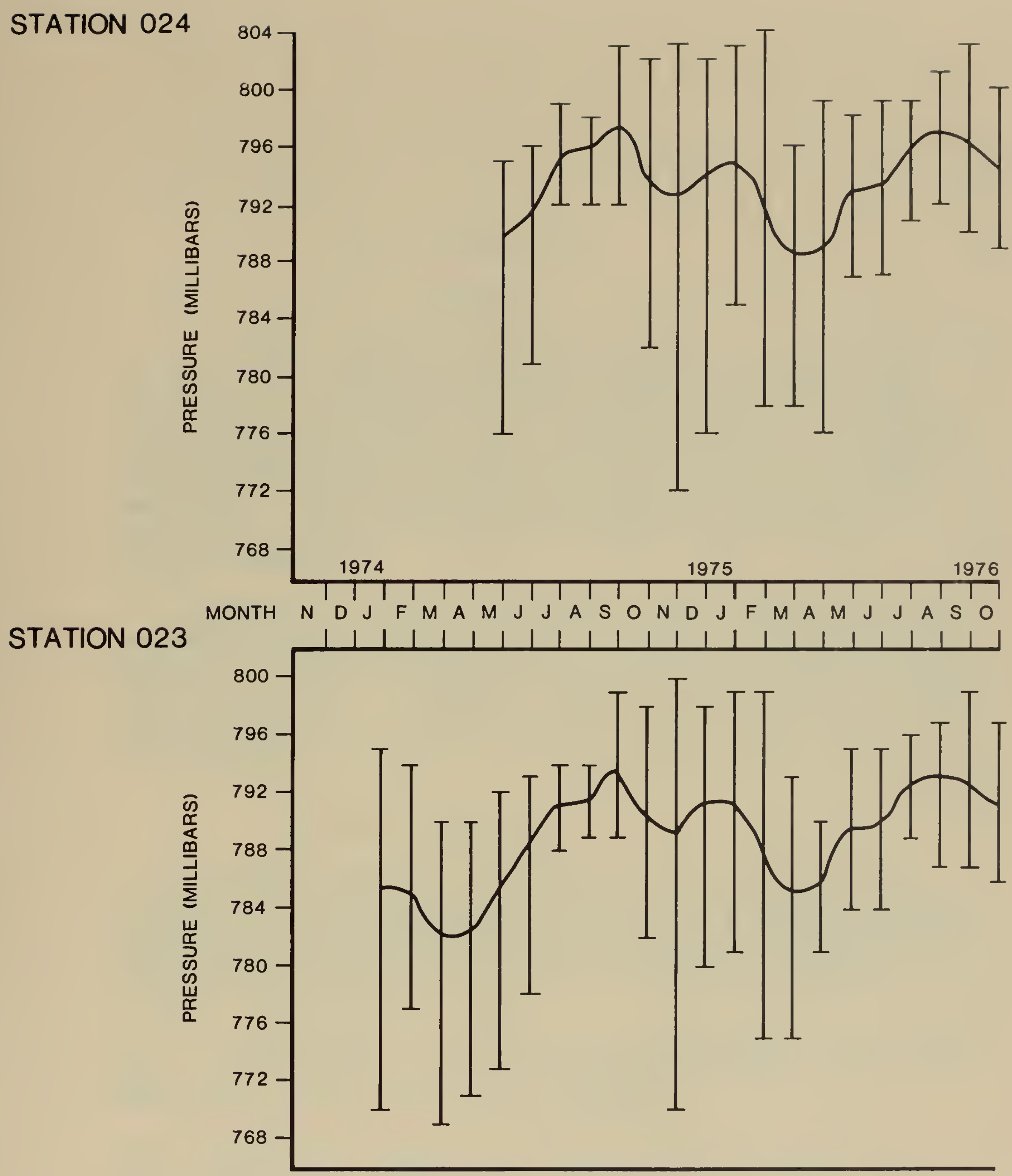


FIGURE 3-15

SEASONAL VARIATIONS IN BAROMETRIC PRESSURE
(MONTHLY AVERAGES WITH DAILY AVERAGE EXTREMA)

3.2 Air Quality

3.2.1 Gaseous Concentrations

3.2.1.1 Rationale

In order that the baseline air quality be well defined, the Oil Shale Lease Environmental Stipulations require that monitoring be conducted for sulfur dioxide, hydrogen sulfide, and suspended particulates for a two-year period. In addition, monitoring is required for hydrocarbons, oxides of nitrogen, and other pollutants as deemed necessary by the area Oil Shale Supervisor. The reader should also consult section 2.3 for monitoring required to comply with federal and state air quality standards.

Pursuant to these requirements, a five station monitoring network was established at or near Tract C-b. Sulfur dioxide, hydrogen sulfide, and suspended particulates were monitored at all five stations. In addition, ozone, nitrogen oxides, methane, total hydrocarbons, and carbon monoxide were monitored at two of the stations.

3.2.1.2 Objectives

- To define baseline air quality at Tract C-b with regard to establishing background levels of all the above-named gaseous constituents. These background levels are to be compared later with readings measured during Tract development to examine possible changes in air quality.

- To provide short-term averages and time series of all air quality parameters in order that temporal variations and long-term trends can be depicted and analyzed.

- To provide air quality data which could be compared to the relevant state and federal air quality standards at averaging times specified in the standards (i.e., 1-hour, 3-hour, 8-hour, 24-hour, and annual). This air quality objective is specifically addressed in Section 3.2.4.

- To provide air quality data which might be correlated with meteorological data in order to gain some insight as to existing pollutant behavior in the region of Tract C-b.

3.2.1.3 Experimental Design

Five trailers were constructed for air quality monitoring at Tract C-b. Each trailer is 8 feet wide and 24 feet long, and has a heating/cooling system which will maintain the interior temperature within a range of 1-3^{0}F compared to an outside temperature range of +110^{0}F to -50^{0}F. The trailers withstand wind speeds up to 150 mph.

Each station is controlled by a minicomputer which also provides real time data processing and generates hard copy data summaries on site. Daily auto-calibration of the air quality analyzers is initiated and controlled by the minicomputer, as is switching and timing for the Hi-Volume samplers. A battery-powered digital clock is accessed by the minicomputer and insures that the correct time is associated with all air quality measurements. A battery backup system provides four-hour reserve power for the entire station in the event of power outages.

All of the air quality analyzers in the appendix (Section A.1) are mounted on slides in an enclosed rack. The air intake manifold is glass and teflon, and is vented outside the trailer. It is enclosed in a heated chamber to prevent condensation of water.

A system status panel continually monitors the state of key elements in the station and provides a display of any problems. This status information is recorded with each packet of air quality data.

The location of the five stations relative to Tract C-b is shown in Figure 2-2. Stations 020, 021, and 022 are located off-Tract in the Piceance Creek valley. Stations 023 and 024 are approximately 600 feet higher, and on the Tract. Station 023 is near the proposed plant site, and Station 024 is at the estimated point of maximum impact so far as air quality is concerned. This network is fully described in Section 2.5.1.

3.2.1.4 Methodology

The air quality analyzers provide a continuous output, and are calibrated daily with a zero and single-point span. During data collection the instrument output voltages are digitized and stored once a second by the minicomputer. Every five minutes an average is calculated and stored. Each hour all of the five minute averages are transferred to both hard copy and two cassette tapes. The status of all lights on the system status panel is also recorded on tape for each five-minute data packet.

Once every few days, the cassette tapes and computer hard-copy are removed and mailed separately to the computer center for processing. These tapes are logged in on receipt, and a history is recorded for each tape as it progresses through the processing sequence. Monthly, quarterly and annual reports are produced which illustrate short-term maxima, long-term averages, diurnal trends, and correlations with various meteorological parameters.

Daily checklists and logbooks are maintained by the station operators. The checklists are mailed with the hard-copy to facilitate editing of the data.

3.2.1.5 Results and Discussion

Data presentations for the gaseous species are presented in the appendix in Section B.2.1. Several types of plots are provided for the air quality data, and these are grouped by pollutant. These include (a) annual time series of daily concentrations to portray long-term trends, and, (b) three dimensional plots of pollutant concentration as a function of wind speed and wind direction to portray the meteorological conditions during which a particular station is most likely to be influenced by a particular pollutant. Additional tables in the appendix, Section B.2.1, include:

(1) The ten highest one-hour sulfur dioxide concentrations.

(2) Maximum concentrations by station by month for SO_2, H_2S, CO, NO, NO_2, O_3 as 1-hour maxima; Methane, Non-Methane HC as 3-hour maxima;

(3) Monthly and annual average concentrations.

The discussion here presents (a) concentrations as time series, (b) correlations with wind speed and direction, and (c) general conclusions.

3.2.1.5.1 Concentrations as Time Histories

3.2.1.5.1.1 Sulfur Dioxide

The minimum-detection limit of the analyzers (13 $\mu g/m^3$) was exceeded only on rare occasions at all five stations. At most stations, SO_2 levels during year one were slightly higher than during year two. Based on the two years of data, no particular seasonal behavior is discernable.

Sulfur dioxide tended to occur as discrete events at all stations, as opposed to a constant background level. This could be an indication that SO_2 levels are influenced by local sources which only influence a particular station under certain conditions.

3.2.1.5.1.2 Hydrogen Sulfide

The minimum-detection limit of the analyzers (7 $\mu g/m^3$) was exceeded only on rare occasions at all five stations. The maximum levels during both baseline years occurred at station 023 with on-Tract stations indicating higher values than off-Tract. Levels during year one tended to be slightly higher at most stations than for year two, but not significantly so.

Hydrogen sulfide generally occurred as discrete events rather than a low, relatively constant background level. This could be an indication that the H_2S may be due to local sources which only influence a particular station under certain conditions.

The global-average background concentrations for SO_2 are one to four $\mu g/m^3$ and for H_2S are three-tenths $\mu g/m^3$.

3.2.1.5.1.3 Ozone

Ozone (O_3) is considered to have a global average background level of between 40 and 80 $\mu g/m^3$.

Since ozone is formed through sunlight it is to be normally expected that concentrations would be higher in the daytime than at night and that concentrations would also be higher in summer with more sunlight than in winter. These two expectations are borne out on Figure 3-16 which shows representative quarterly composite diurnal ozone concentrations for Station 020 for the first year of baseline. Peak magnitude does occur during peak solar insulation and peak width is wider in summer than winter.

In the presence of sunlight ozone and nitric oxide (NO) react in a complex fashion to form nitrogen dioxide (NO_2) and oxidant. Ozone loss reactions are also complex and are dependent on relative amounts of NO, hydrocarbons, and dust particles present. The surviving constituent (NO vs. O_3) at night also depends on the relative amount of each. Destruction of ozone at the ground surface by plants also occurs. Ground surface reactions with plants means that the effects of meteorology (air movement) also exert a variable influence. In summer the loss due to dust has more effect (Figure 3-16) since in winter

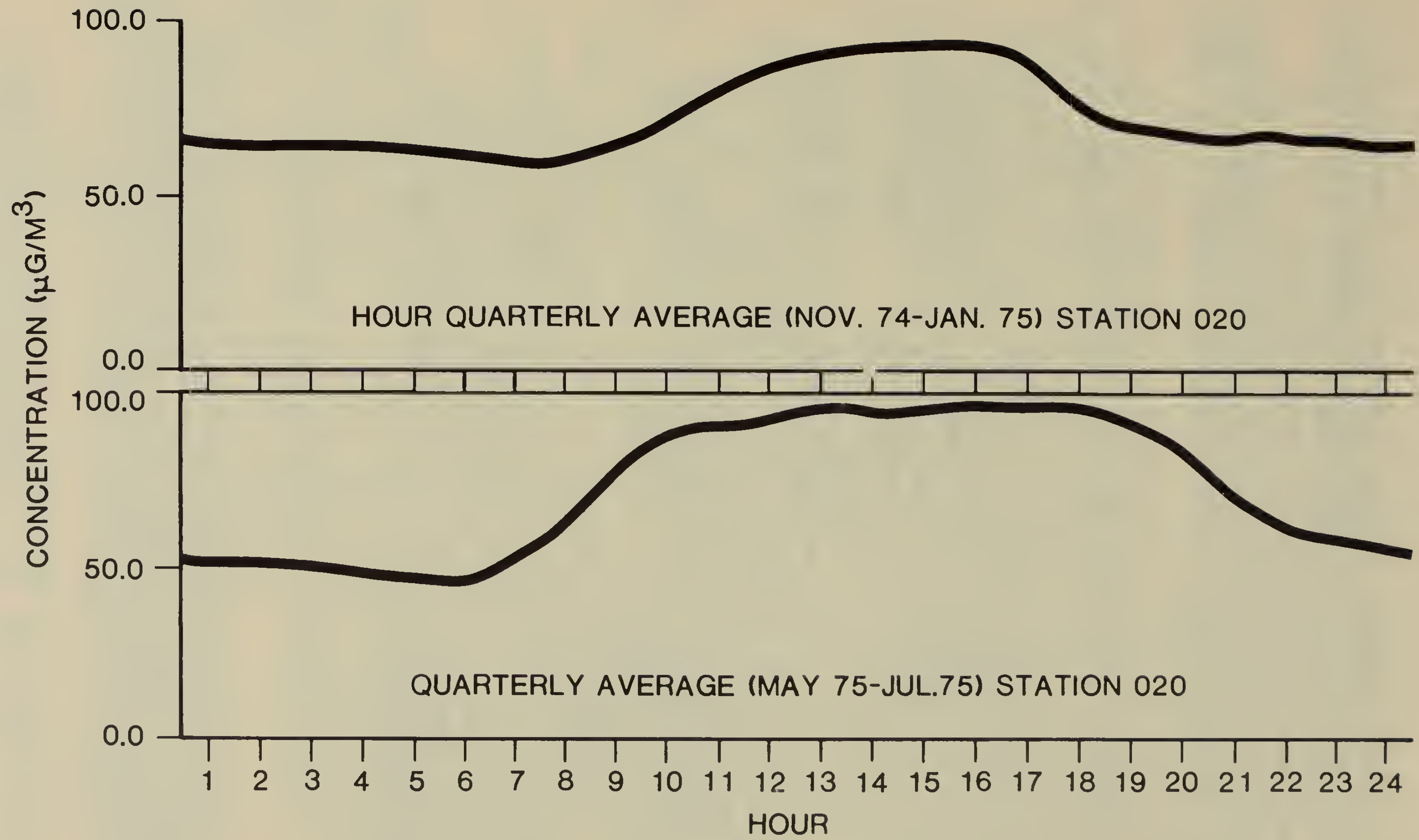


FIGURE 3-16

REPRESENTATIVE QUARTERLY COMPOSITE OF
DIURNAL OZONE VARIATIONS AT STATION 020

the snow cover decreases fugitive particulates. Temperature probably has an important effect also; in winter it is too cold for reactions to develop at the summertime rates - but we do not have enough specific data to prove this point.

Ozone levels observed during baseline were highest during the May to August period. Ozone levels were generally the same during the two summers.

At both stations (020 and 023), ozone levels during February and March of year one were surprisingly high, and much higher than for the same period in year two. The diurnal ozone behavior during this time of year also was unusual, as the ozone levels remained high throughout the night. This lack of ozone destruction at night was possibly due to a lack of scavengers in the air and to the snow cover preventing destruction at the ground, as discussed above. The relatively high levels during the winter months may be due to accumulation of small amounts of ozone generated during the heat of the day.

The highest annual-average ozone levels on the Tract of about 69 $\mu g/m^3$ were reported for both Stations 020 and 023. These levels tended towards the upper range of the normal ozone background levels found in rural, unpolluted areas. The one-hour maximum ozone concentration achieved during baseline was 160 $\mu g/m^3$. Relatively high ozone values occurred with some regularity on the Tract and in Piceance Creek valley.

In addition to the possibility that ozone levels at the Tract are due to the photochemical reactions involving both anthropogenic and naturally occurring hydrocarbons and oxides of nitrogen, extra-regional long-distance transport from the stratosphere may also have profound influence on the ground level ozone concentrations. This topic is deemed to be of enough special importance that it is treated in detail in a separate section, 3.2.3.

3.2.1.5.1.4 Nitrogen Oxides, Nitric Oxide, Nitrogen Dioxide

The ambient air concentrations of oxides of nitrogen (NO_X, NO, NO_2) (both annual and monthly averages) indicated that concentrations frequently occurred above the global-average-background levels of 0.25-2.15 $\mu g/m^3$ for nitric oxide (NO) and 1.9-2.6 $\mu g/m^3$ for nitrogen dioxide (NO_2).

The behavior of these species was similar. At both Stations (020 and 023) the levels were slightly higher during year two. During year one, no particular seasonal trend was

evident, but see below. During year two the highest levels occurred during September and October.

The levels of these species were frequently below the detection limits (10 $\mu g/m^3$). Since a major source of nitrogen oxides is combustion of fuels, it might be expected that local sources will significantly influence a particular monitor.

For the summer quarter depicted for ozone (Figure 3-16) it is interesting to note the corresponding diurnal behavior of NO and NO_2:

	May '75	June '75	July '75
NO	approximately constant at 20 $\mu g/m^3$ in the evening; in the day it varies inversely with O_3	constant @ 7 $\mu g/m^3$ from midnight to 1400 hrs. and drops to 0 for remainder of day	About 0 around the clock
NO_2	about constant around the clock at 5 $\mu g/m^3$	approximately zero around the clock	small buildup in late afternoon to 3 or 4 but almost constant

3.2.1.5.1.5 Carbon Monoxide

Carbon monoxide behavior was erratic at both stations where it was monitored (020 and 023). At Station 023 the highest levels occurred during the winter months during both years. At Station 020 levels were higher than at 023 (probably due to auto traffic) and reached highest levels during May and June. At both stations carbon monoxide levels were significantly higher during the first year of monitoring.

The global-average background carbon monoxide (CO) concentration is 100-200 $\mu g/m^3$. The long term annual and monthly averages of the Tract showed carbon monoxide levels considerably above this demonstrating that the regional atmospheric concentrations are also well above the global background concentration.

3.2.1.5.1.6 Total Hydrocarbons, Methane, Non-Methane Hydrocarbons

At Station 020, total hydrocarbons were quite uniform throughout the first year. Two peaks occurred during May, each of several days duration. Early in year two, the total hydrocarbons decreased slightly and remained at a fairly constant level. In June, however, they returned to the same level and variations as exhibited during the first year.

At Station 023, a few peaks were noted in January of year one. From February of year one through February of year two the total hydrocarbon levels were remarkably constant. From February through August of year two, the levels were high and erratic. During the last two months of year two, the total hydrocarbon levels were almost identical to those observed for the same period in year one.

The behavior of methane at Station 020 was relatively constant in year one except for an October peak; in year two a seasonal summer increase was noted. At Station 023, methane was relatively constant throughout the two year period. Year two was more erratic than year one for Station 023, but the overall yearly averages were quite similar; notable methane peaks occurred during February and June of year two. Both annual and monthly averages for methane were in general agreement with the global-average-background range of 814-977 $\mu g/m^3$.

Non-methane hydrocarbons were generally quite low at Station 020 for the two year period. The maximum levels occurred during April of year one. There were a few excursions when the federal guideline for non-methane hydrocarbons was exceeded. At Station 023, levels were higher than at Station 020 and were relatively lower in the first year compared to the second. During much of year two the non-methane hydrocarbon levels were quite high. Only during September were the daily averages consistently below the federal guideline. The highest levels occurred during the April through October period of the second year.

Over the two year period, 19 readings in excess of standards have been recorded at Station 020 and 243 at Station 023. (See Section 3.2.4 for further explanation.) By season, these are distributed as follows:

Season	Number of Excesses at Station 020	Station 023
Winter	0	42
Spring	13	66
Summer	1	86
Fall	5	49

It is reasoned that the bulk of these excesses are due to natural causes, probably from terpenes naturally emitted from sagebrush. Predominant wind direction for the high readings at Station 020 in Piceance Creek valley is down-creek. Upwind of Station 020 lands are devoted primarily to agricultural grazing. Predominant wind directions for the high readings at Station 023 vary from the ESE to the SSW compass sectors which contain the upland-sage-brush community. Furthermore, Halligan 1975 supports the contention that terpenes from sagebrush are greatest in concentration in late summer and lowest in concentration in winter.

3.2.1.5.1.7 Representation of Baseline Values

Table 3-15 lists the 24-month summary of the two highest concentrations of gaseous and particulate constituents for each station for averaging times corresponding to standards (plus 1-hour and 5-minute).

For modeling purposes the EPA recommends use of baseline annual averages, as presented in Table 3-15.

For general baseline reference the EPA has very recently recommended composite quarterly tables as contained in their SAROAD program format which includes the following items:

Station
Quarter of Year
Number of Observations
Number of Times Standard Exceeded
Minimum Observed
Frequency Distribution of Concentrations
  by Constituent - 10, 30, 50, 70, 90, 95, 99 percent
  e.g. for SO_2 presented for 24-hour, 3-hour and
  1-hour.
Maximum
2nd Maximum
Arithmetic Mean
Geometric Mean
Geometric Standard Deviation

Table 3-15

24-MONTH SUMMARY OF TWO-HIGHEST CONCENTRATIONS
(November 1974-October 1976)
($\mu g/m^3$)

a. Station 020

Parameter	Highest Annual Average*	Maximum 24 Hour Value		Time	Maximum 8 Hour Value		Time	Maximum 3 Hour Value		Time	Maximum 1 Hour Value		Time	Maximum 5 Minutes Value		Time
SO_2	.8	1) 30.2	3/7/75	10:00				1) 79.3	9/17/76	21:00	1) 189.1	9/18/76	3:00	1) 523.6	9/17/76	23:40
		2) 25.6	5/22/76	8:00				2) 66.0	9/18/76	3:00	2) 111.6	9/18/76	5:55	2) 435.0	9/18/76	2:50
H_2S	.1										1) 30.9	4/5/76	15:55	1) 72.0	4/5/76	16:05
											2) 21.7	6/15/75	6:00	2) 70.6	8/23/75	10:35
Particulate	9.5	1) 133.	11/29/74													
		2) 79.	4/2/76													
THC	930.6							1) 2294.6	5/13/75	6:00				1) 3256.2	8/20/75	12:15
								2) 2200.8	5/20/75	6:00				2) 3256.2	7/21/76	19:20
CH_4	851.7							1) 1298.0	2/3/75	6:00				1) 3256.2	7/21/76	19:25
								2) 1219.5	12/8/74	6:00				2) 3254.2	7/14/75	18:55
NMHC	74.3							1) 707.7	4/22/75	6:00				1) 2070.9	12/5/74	15:55
								2) 478.3	4/10/75	6:00				2) 1820.2	12/4/74	1:00
O_3	68.8										1) 160.4	6/26/75	14:00	1) 314.5	3/15/75	14:05
											2) 148.2	8/25/76	11:05	2) 289.0	12/12/74	11:50
NO_X	21.0										1) 303.3	9/26/76	16:50	1) 312.7	9/26/76	17:35
											2) 287.1	9/22/76	7:25	2) 295.8	9/27/76	8:00
NO	14.0										1) 244.0	9/27/76	7:25	1) 250.9	9/27/76	[illegible]:30
											2) 226.1	9/18/76	0:05	2) 234.0	9/18/76	10:25
CO	1080.0				1) 4501.9	6/3/75	21:55				1) 4650.9	6/4/75	4:55	1) 5698.0	1/11/75	19:40
					2) 3721.8	6/4/75	6:55				2) 4640.0	6/3/75	22:10	2) 5698.0	1/25/75	10:00
NO_2	5.0										1) 116.5	5/15/76	3:20	1) 121.7	8/30/76	12:45
											2) 106.4	5/14/76	11:30	2) 108.6	9/26/76	17:35

*Arithmetic

Table 3-15

24-MONTH SUMMARY OF TWO-HIGHEST CONCENTRATIONS
(November 1974-October 1976)
($\mu g/m^3$)

b. Station 021

Parameter	Highest Annual Average*	Maximum 24 Hour Value	Maximum 24 Hour Time	Maximum 8 Hour Value	Maximum 8 Hour Time	Maximum 3 Hour Value	Maximum 3 Hour Time	Maximum 1 Hour Value	Maximum 1 Hour Time	Maximum 5 Minutes Value	Maximum 5 Minutes Time
SO_2	1.3	1) 43.1 2) 18.6	6/16/75 9:00 11/25/74 22:00			1) 66.4 2) 61.1	6/16/75 12:55 6/16/75 16:00	1) 67.9 2) 65.8	6/16/75 13:45 6/16/75 15:15	1) 640.0 2) 117.2	1/26/75 15:05 6/16/75 13:00
H_2S	.6							1) 58.9 2) 52.1	11/18/74 1:25 8/19/76 8:10	1) 130.1 2) 107.9	8/19/76 9:00 1/18/75 10:05
Particulate	10.2	1) 125.0 2) 97.0	4/25/75 5/20/75								
THC											
CH_4											
NMHC											
O_3											
NO_X											
NO											
CO											
NO_2											

*Arithmetic

Table 3-15

24-MONTH SUMMARY OF TWO-HIGHEST CONCENTRATIONS
(November 1974-October 1976)
($\mu g/m^3$)

c. Station 022

Parameter	Highest Annual Average*	Maximum 24 Hour Value	Maximum 24 Hour Time	Maximum 8 Hour Value	Maximum 8 Hour Time	Maximum 3 Hour Value	Maximum 3 Hour Time	Maximum 1 Hour Value	Maximum 1 Hour Time	Maximum 5 Minutes Value	Maximum 5 Minutes Time
SO_2	.8	1) 14.1	6/11/75 3:00			1) 26.9	6/12/75 0:00	1) 27.4	6/12/75 0:00	1) 140.7	2/22/75 9:45
		2) 13.9	5/23/75 10:00			2) 25.6	6/12/75 22:30	2) 27.1	6/12/75 1:15	2) 135.5	3/23/75 9:35
H_2S	.3							1) 14.3	2/28/75 20:55	1) 84.4	3/3/75 9:30
								2) 14.1	3/1/75 0:00	2) 84.4	3/23/75 9:35
Particulate	8.2	1) 154.0	11/28/74								
		2) 116.0	12/1/74								
THC											
CH_4											
NMHC											
O_3											
NO_x											
CO											
NO_2											

*Arithmetic

Table 3-15

24-MONTH SUMMARY OF TWO-HIGHEST CONCENTRATIONS
(November 1974-October 1976)
($\mu g/m^3$)

d. Station 023

Parameter	Highest Annual Average*	Maximum 24 Hour Value	Maximum 24 Hour Time	Maximum 8 Hour Value	Maximum 8 Hour Time	Maximum 3 Hour Value	Maximum 3 Hour Time	Maximum 1 Hour Value	Maximum 1 Hour Time	Maximum 5 Minutes Value	Maximum 5 Minutes Time
SO_2	1.0	1) 43.0	1/1/75 11:00			1) 87.7	12/21/74 0:10	1) 97.9	12/21/74 1:55	1) 200.6	12/22/74 14:45
		2) 32.4	3/22/76 2:00			2) 59.2	8/20/75 4:00	2) 59.9	8/20/75 4:15	2) 127.0	1/23/75 15:50
H_2S	1.7							1) 71.2	7/9/75 0:10	1) 113.5	3/9/75 10:15
								2) 70.1	7/9/75 1:20	2) 91.3	2/22/75 14:35
Particulate	11.2	1) 171.0	3/22/75								
		2) 123.0	9/21/75								
THC	1531.9					1) 3256.2	6/27/76 6:00			1) 3256.2	4/20/76 12:25
						2) 3256.2	6/28/76 6:00			2) 3256.2	6/24/76 8:15
CH_4	963.2					1) 1533.8	2/21/76 6:00			1) 3254.2	8/6/76 2:15
						2) 1472.1	2/22/76 6:00			2) 3250.9	8/15/76 7:25
NMHC	571.1					1) 2596.6	6/27/76 6:00			1) 2763.2	9/17/75 0:25
						2) 2578.3	6/26/76 6:00			2) 2752.1	8/11/76 0:40
O_3	68.0							1) 152.2	6/26/75 13:05	1) 781.5	2/23/75 22:20
								2) 145.9	3/8/75 11:40	2) 455.2	3/8/75 11:50
NO_X	3.9							1) 233.6	9/24/76 9:05	1) 868.7	9/24/76 9:30
								2) 197.5	9/24/76 5:20	2) 292.1	10/27/76 9:15
NO	2.4							1) 136.7	9/24/76 9:00	1) 793.8	9/24/76 9:30
								2) 114.2	1/17/75 9:55	2) 228.0	1/10/75 13:00
CO	1351.8			1) 2894.1	11/25/75 20:55			1) 3538.8	1/6/76 13:20	1) 5539.8	11/14/75 10:45
				2) 2729.5	11/11/75 14:55			2) 3300.7	1/11/76 21:50	2) 5382.6	6/24/75 10:45
NO_2	1.5							1) 177.2	9/24/76 6:50	1) 335.1	9/24/76 5:50
								2) 169.1	9/24/76 5:20	2) 215.3	10/27/76 9:15

*Arithmetic

Table 3-15

24-MONTH SUMMARY OF TWO-HIGHEST CONCENTRATIONS
(November 1974-October 1976)
($\mu g/m^3$)

e. Station 024

Parameter	Highest Annual Average*	Maximum 24 Hour Value	Time	Maximum 8 Hour Value	Time	Maximum 3 Hour Value	Time	Maximum 1 Hour Value	Time	Maximum 5 Minutes Value	Time
SO_2	1.3	1) 112.1	8/22/76 21:00			1) 77.9	12/10/74 6:05	1) 128.5	12/10/74 6:20	1) 2586.7	8/23/76 13:55
		2) 25.8	3/3/75 12:00			2) 53.9	5/2/75 3:10	2) 113.1	8/23/76 10:30	2) 218.8	10/11/75 20:00
H_2S	.4							1) 70.9	6/22/75 19:05	1) 148.1	6/22/75 17:30
								2) 62.6	4/14/75 0:35	2) 143.9	6/23/75 8:15
Particulate	8.5	1) 178.0	11/27/74								
		2) 162.0	11/29/74								
THC											
CH_4											
NMHC											
O_3											
NO_X											
NO											
CO											
NO_2											

*Arithmetic

C-b data presently are not tabulated in this format. Consideration may be given toward this at a future date; concensus by the EPA regarding selection of this format was recently arrived at after termination of the C-b baseline program and associated documentation.

3.2.1.5.2 Correlations with Wind Direction and Speed

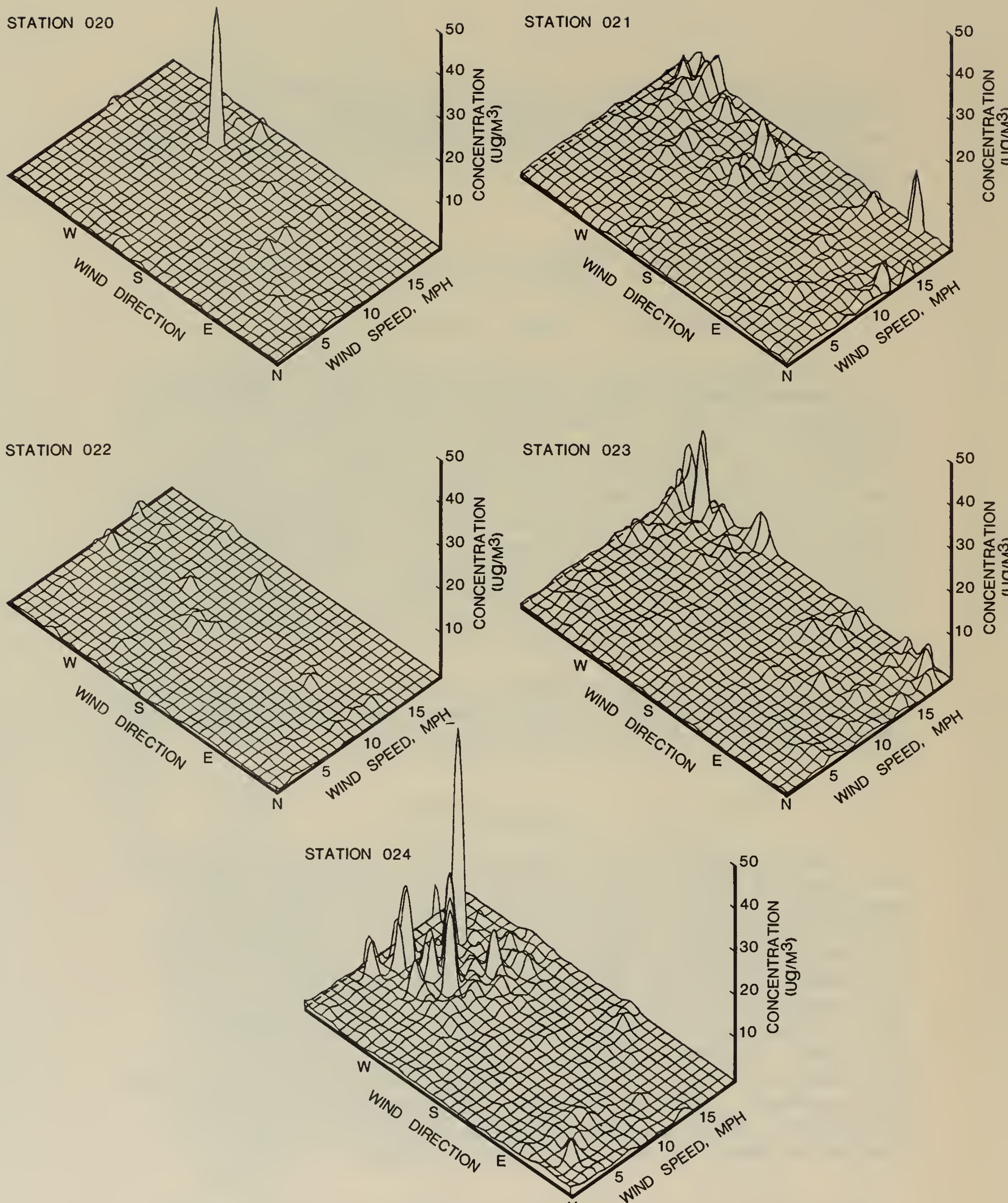
3.2.1.5.2.1 Sulfur Dioxide

The three dimensional plots of percentage of occurrences of 5-minute samples of gas concentration levels as functions of wind speed and direction are shown for SO_2 on Figure 3-17. At all stations except 022, peak SO_2 concentrations correlate with winds from the southwest to northwest quadrant. Station 020 provides a striking example of a monitor influenced by a specific set of meteorological conditions, namely a 14 mph wind from the west-southwest. Station 021 shows only a slight preference for northwest winds. Station 022 shows no particular dependence of SO_2 on wind direction. SO_2 at Station 023 is favored by northwest winds greater than 15 mph. Station 024 is favored by west-northwest winds from 5 to 15 mph.

Thus, higher concentrations in most cases correspond to wind speeds over 10 mph. In most cases, peak concentrations do not correspond to the prevailing wind direction.

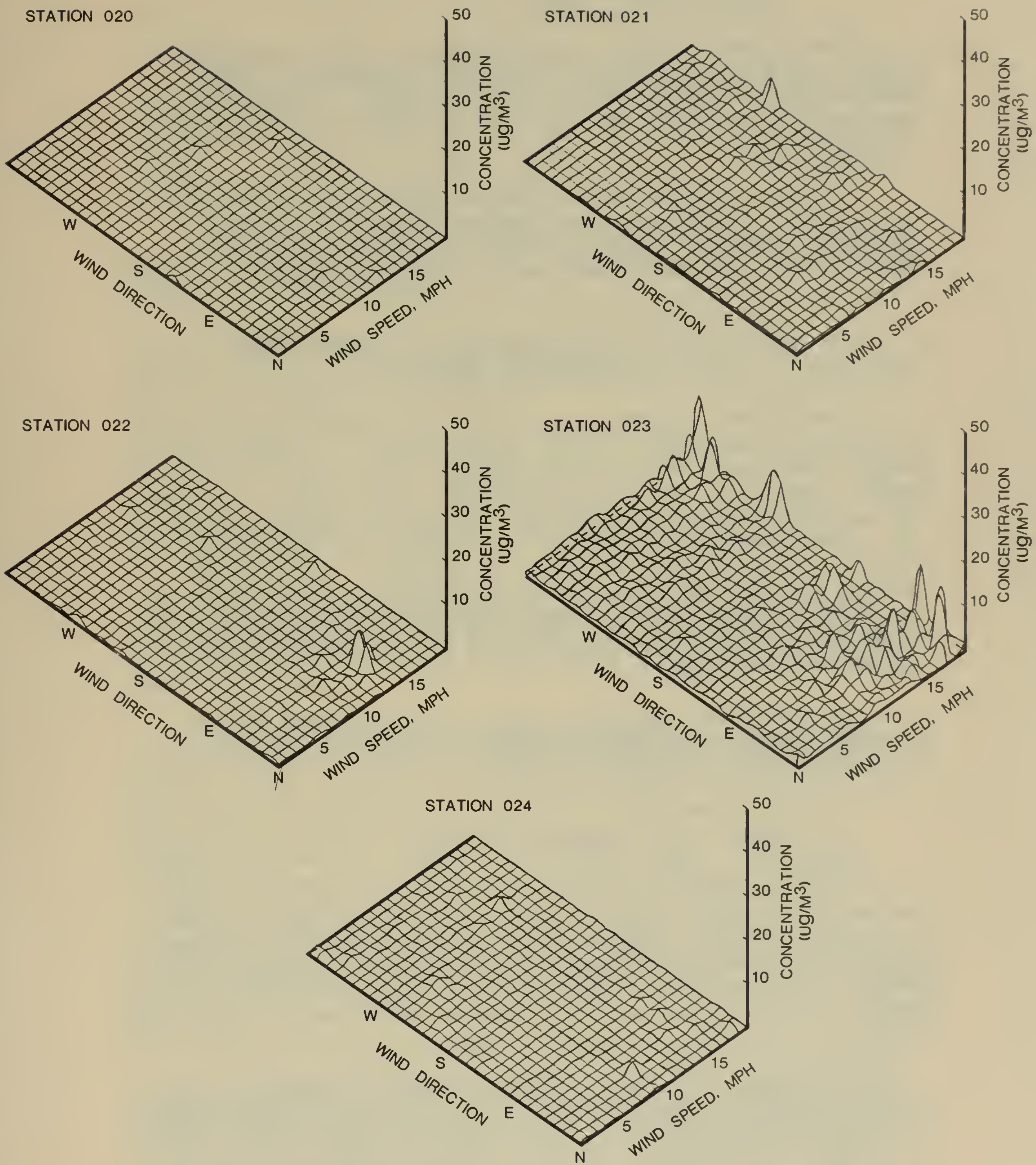
3.2.1.5.2.2 Hydrogen Sulfide

Concentrations as a function of wind speed and direction are shown on Figure 3-18. Station 020 does not exhibit any particular preference for wind direction; only minor peaks in concentration occur. Possibly the monitor is being influenced by several different minor sources of H_2S. Station 021 also has numerous peaks on the graph, with the major one occurring at a wind speed of 18 mph, and a westerly wind. For Station 022, the major peak occurs with 12 mph winds from the north-northeast. Several significant peaks occur at Station 023, all with winds above 10 mph, and with directions of north, west, and northeast. Station 024 has no major peaks but numerous minor ones. Thus, as with SO_2 there is a correlation of concentration peaks at wind speeds above 10 mph.



5-MINUTE SULFUR DIOXIDE CONCENTRATIONS AS FUNCTIONS OF WIND SPEED AND DIRECTION, 1974-1976

FIGURE 3-17



5-MINUTE HYDROGEN SULFIDE CONCENTRATIONS AS FUNCTIONS OF WIND SPEED AND DIRECTION, 1974-1976

FIGURE 3-18

3.2.1.5.2.3 Ozone

The figure for ozone concentration is given in appendix B.2.1. Ozone did not exhibit remarkable dependence on wind speed or wind direction at Station 023. Since ozone tends to be a regional problem, and since 023 has good exposure, this is not surprising.

Station 020 generally exhibited higher ozone levels in the southwest-north quadrants than in the south-east-north quadrants. Station 020 is in Piceance Creek valley, and has restricted air movements confined by the valley walls.

3.2.1.5.2.4 Nitrogen Oxides, Nitric Oxide, Nitrogen Dioxide

These three figures are presented in appendix B.2.1. At Station 020, all three of these species were not strongly dependent on wind direction, but were slightly higher with easterly winds. Generally, the levels decreased as wind speeds increased. The concentrations were higher for Station 020 than for Station 023. Since Station 020 is next to a major road, and Station 023 is in an isolated area this is to be expected. The road by Station 020 runs in an east-west direction near the station in the Piceance Creek valley. Automobile emissions may tend to be trapped in this valley, obscuring the true direction of the source to some extent.

At Station 023 there is a very slight increase in the nitrogen species with northeast winds. The levels generally decrease with increasing wind speed.

3.2.1.5.2.5 Carbon Monoxide

At Station 020 carbon monoxide does not exhibit a strong preference for wind direction at low wind speeds (below 5 mph). Principle source of emissions here is estimated to be the automobile. These emissions appear to be fairly well mixed in this valley. At higher wind speeds (above 10 mph), there is a notable drop in carbon monoxide from the north, while significant peaks occur from the west and north-west.

At Station 023, there is not a strong correlation between carbon monoxide levels and wind direction. This station is on a plateau approximately three miles south of Station 020, and air flow is unrestricted. Except for the possibility of decaying vegetation, no sources of CO are known near this station.

3.2.1.5.2.6 Total Hydrocarbons, Methane, Non-Methane Hydrocarbons

At wind speeds less than 10 mph, total hydrocarbons are not dependent on wind direction at Station 020. At speeds above 10 mph, there is a notable decrease when winds are from the northeast. Peaks occur at this wind speed from the west and south. At Station 023 total hydrocarbons are not dependent on wind direction even at the higher wind speeds.

Station 020 exhibited slightly higher methane levels with westerly winds. Station 023, however, showed no dependence of methane on wind direction.

Predominant wind direction for high NMHC readings at Station 020 in Piceance Creek valley is down-creek. Predominant wind directions for high readings at Station 023 vary from the ESE to SSW compass sectors.

3.2.1.5.3 Conclusions

Conclusions regarding gaseous concentrations are as follows:

1) SO_2 and H_2S are near the minimum detectable levels of the instruments most of the time. Peak readings correlate best with wind speeds over 10 mph - but not in the prevailing wind direction.

2) Ozone readings are generally higher in the daytime than at night and higher in summer than winter. Ozone loss rates at night are dependent on nitric oxide, hydrocarbons, and dust. Reading peaks are essentially independent of wind direction on the plateau, but in Piceance Creek valley are slightly higher with westerly (up-creek) winds. The subject of ozone transport is separately treated in Section 3.2.3.

3) Oxides-of-nitrogen species behaved similarly, as a group with no major seasonal trends. These species are not strongly dependent on wind direction but concentrations decreased with increasing speed.

4) Carbon monoxide was seasonally highest in winter and higher during the first year than the second. It is higher in concentration in Piceance Valley than on Tract, probably because its major source appears to be auto traffic in Piceance Creek valley. There is no wind direction preference at low wind speeds.

5) Total hydrocarbons have reached some high values in somewhat erratic fashion. At Station 020 concentration decreases for winds over 10 mph from the northeast. At Station 023 concentrations appear less dependent on wind direction.

6) Methane values are relatively constant with no major effects of wind direction.

7) Non-methane hydrocarbons are derived from total hydrocarbons less methane and as such (the often small differences in large numbers) are relatively inaccurate. Concentrations at Station 023 are very high in the summer (often exceeding standards) and are hypothesized as being caused by terpenes from sagebrush. Concentrations at Station 020 are relatively low. High concentrations on the plateau correspond to winds from the ESE to SSW sectors; those in Piceance Creek valley correspond to the down-creek direction.

8) Specific instrumentation is discussed in the appendix in Section A.1 and is judged to be adequate with the following exceptions:

a) As mentioned above, NMHC are obtained by subtractive techniques; however, no alternative commercial continuous monitoring technique appears available.

b) The NOX instrument is often noisy since its pump was not designed for 7000 foot operation.

c) Consideration should be given to separate measurement of carbon monoxide, rather than via the gas chromatograph.

d) Inasmuch as most of the SO_2 readings were below the minimum detectable limit of the instrument, consideration should be given to the improved version of the instrument over that used during the baseline.

9) The reporting of data in SAROAD type format for utilization as a baseline reference and to judge trends in the future represents a sizeable future data management task. This suggestion was received after completion (and documentation) of the baseline. Frequency of data gathering as fully-automated five-minute averages is judged to be adequate and necessary and should be continued.

3.2.2 Particulate Concentrations

3.2.2.1 Rationale

Monitoring for suspended particulates is required by the Oil Shale Lease Environmental Stipulations and by federal and state air quality regulations.

3.2.2.2 Objectives

- To define baseline suspended particulate concentrations at Tract C-b. These background levels are later to be compared with readings measured during Tract development to examine possible changes in air quality with respect to particulates.

- To provide baseline particulate data which can be compared to the relevant state and federal air quality standards. This objective is treated separately in Section 3.2.4.

- To define size distributions of suspended particulates at Tract C-b, including those in the respirable range.

- To attempt to correlate high particulate loadings with other significant air quality and meteorological parameters.

3.2.2.3 Experimental Design

Suspended particulates were measured according to the federal reference method using high volume samplers. Each of the five monitoring stations (Figure 2.2) was equipped with four samplers. A 24-hour sample was collected every day at each station from one sampler (with the sample collected from midnight to midnight). The cycling of the samplers at each station was controlled by the computer at that station so that sequential samples could be collected even if the station were not attended daily.

The high volume samplers were mounted on top of the monitoring stations, with the intake approximately 15 feet above ground level.

Quarterly sampling of particulates for size distributions in the respirable range was achieved over eight quarters utilizing an Anderson sizer on the head of the high-volume sampler at Station 023.

3.2.2.4 Methodology

The high volume samplers used in this application pull a measured quantity of air into a specially designed shelter and through a weighed filter. The air flow during the 24-hour sampling period is continuously recorded. The filter is weighed initially at a controlled humidity, and after exposure is readjusted to this same humidity before reweighing. A twenty-four-hour average particulate concentration (mass per unit volume) is calculated from the difference between the final and initial weights divided by the total air flow.

3.2.2.5 Results and Discussion

This section is divided into three sub-sections: (a) concentrations, (b) correlations with other parameters, and (c) size distributions in the respirable ranges.

3.2.2.5.1 Concentrations

The following particulate concentration data are presented in the appendix, Section B.2.2:

1) Plots of two annual time series of 24-hour concentrations by station.

2) A table of monthly average concentrations by station.

A table of 24-month summary of the 10 highest 24-hour readings by station was presented in Section 3.2.1 as Table 3-15.

The monthly average ambient concentrations of particulates exhibit a seasonal trend with lowest concentrations occurring during the winter months when the snow cover, lower wind speeds and decreased level of activity in the area tend to reduce the amount of fugitive dust. Peaks during the April, May, and June period correlate extremely well for all the stations for each year. The correlation later in the year is still fairly good, with differences possibly due to variations in the growth of vegetation near the stations. For the valley stations, differences in the late fall could be in part due to agricultural activities such as harvesting alfalfa. Four readings in excess of standards occurred during the first year, none during the second.

During the spring of each year, an excellent correlation exists between the occurrence of peaks at each station. Vegetative cover is probably at a minimum at the start of this period. Later in the year, some differences occur among peaks

at the various stations, possibly due to differences in development of vegetation.

The particulate levels are not greatly different among the five stations. Stations 021 and 023 tend to be slightly higher than the others. The general seasonal particulate behavior is quite similar at the various stations.

Wind speeds affect the ambient particulate concentrations and higher particulate filter loadings often result as persistent wind speeds reach 10-15 mph.

As mentioned above, many factors could affect the concentrations of particulates. These are now investigated by the statistical techniques of correlation analysis.

3.2.2.5.2 Particulate Concentration Correlations

The objective of this study was to determine if significant correlations existed between daily particulate concentrations and observations of several air quality and meteorological parameters taken at the same time.

Observations of daily values for the following parameters were utilized:

- particulate mean concentrations - $\mu g/m^3$
- mean hourly wind speed at trailer 023, 30 foot - mph
- total daytime solar radiation - langleys
- mean ozone concentration - $\mu g/m^3$
- mean relative humidity - percent
- mean temperature - degrees Fahrenheit
- total precipitation - inches
- mean monthly soil moisture - percent
- maximum hourly wind speed - mph

These observations were tabulated for the dates visual range observations were taken (i.e., every sixth day) and are shown in Table 3-16.

Table 3-16

INPUT DATA FOR THE PARTICULATE CONCENTRATION CORRELATION STUDY

DAILY VALUES AT STATION 023

DATE MM DD YY	VISUAL RANGE (mi.)	PART. (μg/m³)	SPEED 30' (mph)	SOLAR RAD. (LANG.)	OZONE (μg/m³)	REL. HUM. (%)	TEMP. (°F)	TOTAL PRECP (in)	SOIL MOIS-TURE (%)*	MAX. WIND (mph)
09 25 75	103	18	5	469	53	19	57	.00	.171	15.
09 26 75	87	20	7	384	54	22	59	.00	.171	23.
09 27 75	59	27	5	459	51	32	50	.00	.172	14.
10 03 75	93	10	4	427	50	21	58	.00	.172	13.
10 09 75	116	13	7	382	43	28	46	.00	.172	16.
10 15 75	66	8	4	396	37	49	41	.00	.174	14.
10 21 75	99	17	8	342	50	22	53	.00	.174	15.
10 27 75	63	27	14	224	36	60	40	.00	.176	29.
11 02 75	106	1	3	261	35	52	41	.00	.176	11.
11 08 75	66	1	4	14	27	95	33	.04	.178	12.
11 14 75	130	5	5	204	36	28	41	.00	.180	13.
11 20 75	80	2	3	205	39	69	16	.00	.182	8.
11 26 75	95	5	10	20	43	66	13	.00	.185	21.
12 02 75	98	2	5	183	40	60	36	.00	.188	13.
12 08 75	88	4	3	112	34	58	36	.00	.192	7.
12 14 75	32	4	8	83	42	85	11	.00	.196	17.
12 20 75	109	1	2	183	38	56	24	.00	.201	7.
12 27 75	53	2	10	71	45	56	25	.00	.207	26.
01 02 76	44	2	2	224	41	77	3	.00	.210	8.
01 08 76	66	2	9	73	35	57	27	.00	.214	20.
01 14 76	102	1	5	218	45	44	24	.00	.218	16.
01 20 76	91	6	2	290	35	61	23	.00	.224	6.
01 26 76	57	5	5	102	35	68	14	.00	.229	15.
02 01 76	105	1	4	302	41	41	34	.00	.234	9.
02 07 76	46	6	4	265	31	77	28	.00	.240	15.
02 13 76	85	1	4	348	41	62	36	.00	.248	11.
02 19 76	102	1	16	353	43	55	32	.09	.255	33.
02 25 76	79	7	7	377	45	41	33	.00	.260	20.
03 02 76	37	45	9	174	45	83	22	.51	.267	23.
03 08 76	61	8	2	402	53	60	27	.00	.272	6.
03 14 76	65	3	13	316	45	58	33	.00	.276	26.
03 20 76	85	22	10	505	39	46	23	.00	.278	22.
03 26 76	75	2	5	564	43	62	25	.00	.278	12.
04 01 76	101	24	15	554	47	29	47	.00	.278	31.
04 07 76	45	4	4	188	37	78	36	.00	.278	10.
04 13 76	78	60	14	331	66	67	40	.00	.277	33.
04 19 76	56	3	4	326	64	80	36	.00	.276	14.
04 25 76	72	6	10	222	86	30	48	.00	.275	25.
05 01 76	75	16	4	672	78	38	46	.00	.273	14.
05 07 76	56	3	4	278	72	71	46	.00	.271	14.
05 13 76	76	8	6	699	82	38	54	.00	.268	18.
05 19 76	58	16	7	335	76	47	56	.13	.266	24.
05 25 76	65	6	10	195	90	46	56	.00	.261	26.
05 31 76	88	13	7	604	82	47	56	.00	.256	14.
06 06 76	59	24	10	526	78	38	63	.05	.250	24.
06 12 76	84	9	9	507	70	50	50	.00	.245	21.
06 18 76	68	4	8	686	64	64	50	.00	.240	20.
06 24 76	81	15	6	705	94	43	52	.00	.233	17.
06 30 76	62	33	10	615	78	42	67	.00	.226	28.
07 06 76	71	33	8	579	70	35	74	.00	.219	19.
07 12 76	61	53	8	566	90	45	71	.00	.213	23.
07 18 76	62	14	7	456	59	79	63	.31	.206	20.
07 24 76	92	14	6	509	92	45	69	.00	.200	13.
07 30 76	68	17	6	568	72	53	69	.07	.193	25.
08 05 76	96	7	5	665	72	43	62	.00	.186	17.
08 11 76	18	8	10	438	59	60	59	.10	.178	24.
08 17 76	94	23	13	346	49	47	67	.00	.169	25.
08 23 76	69	12	9	501	53	55	66	.00	.161	19.
08 29 76	109	8	6	532	59	39	67	.00	.152	17.

*% Moisture by volume

The data shown in Table 3-16 were used as inputs to two computer programs. The first program was a multiple linear regression model that was used to compute correlation coefficients of each air quality parameter with particulate concentration. Other statistics included the mean value, standard deviation, and multiple regression coefficients. This program was used in an iterative manner where parameters were dropped out one at a time in the iterations to focus on the predictive capability of the remaining parameters for particulate concentration. Discussion of the multiple linear regression model is presented in the appendix, Section B.2.4. The second program was a polynomial-fit model with plotted output. First and second degree polynomials were computed and plotted to provide visibility to the data.

A summary of the particulate concentration correlations is shown in Table 3-17. These summary data were derived from computer runs using the multiple linear regression program. Particulate concentration was the dependent variable in each of these runs (iterations), with 12 independent variables identified in the parameter column. The first eight parameters are designated "primary" independent variables with the last four representing squared and cubed values of mean daily wind speed and maximum daily wind speed respectively and designated as "secondary".

The coefficient of correlation is the measure of the independence of two variables. If the two variables are independent, the coefficient of correlation (r) is zero, or near zero, since r is an estimate to the true population measure of independence. The hypothesis of independence between the two variables can be tested at various confidence levels under the assumption that both are normally distributed. The 95 percent confidence interval for r in a sample size of 59 is:

$$- .256 < r < + .256$$

All independent variables except relative humidity and soil moisture are outside this interval, indicating there is significant correlation between particulate concentration and parameters other than humidity and soil moisture at this selected confidence level. The highest correlation is with maximum wind speed with r = .500. The negative sign in the table for relative humidity means an increase in relative humidity results in a reduction in particulate concentration.

The remaining part of Table 3-17 presents the results of multiple linear regressions obtained by first running the computer program with the eight primary independent variables and then with both primary and secondary variables. Particulate concentration is the dependent variable in all computer runs. The multiple correlation coefficient for the first run is .620. For this case the

Table 3-17

SUMMARY OF PARTICULATES CORRELATION AND REGRESSION ANALYSIS

PARAMETER	UNITS	MEAN	STD DEV	COEF CORR	MULTIPLE REGRESSION COEFFICIENTS PRIMARY VARIABLES								MULTIPLE REGRESSION COEFFICIENTS, PRIMARY & SECONDARY VARIABLES			
1. WIND SPEED-30'	mph	6.95	3.43	.432	.432	.386										
2. SOLAR RADIATION	lang.	365.	185.	335.	.011	.010	.010	.011	.012	.020	.018		.011	.011	.013	.011
3. OZONE	$\mu g/m^3$	54.4	18.2	.363	.062	.043	.033						.067	.065	.053	.064
4. REL. HUMIDITY	%	52.2	17.5	-.201	-.046	-.050	-.051	-.047					-.077	-.079	-.074	-.081
5. TEMPERATURE	^oF	42.9	17.5	.410	.068	.096	.094	.109	.128				.056	.057	.082	.095
6. PRECIPITATION	in	.022	.080	.286	40.3	39.8	38.7	38.4	35.1	35.1			44.0	43.6	44.6	45.9
7. SOIL MOISTURE	%	.221	.040	.071	-14.1											
8. MAX. WIND SPEED	mph	17.8	6.82	.500	.486	.480	.671	.684	.692	.764	.858	.938	.405	.500	-1.14	-.405
9. (WIND SPEED)^2	$(mph)^2$	58.6	56.7	.390									.033			
10. (WIND SPEED)^3	$(mph)^3$	586.	847.	.340										.001		
11. (MAX. WIND SPEED)^2	$(mph)^2$	356.	257.	.501											.047	
12. (MAX. WIND SPEED)^3	$(mph)^3$	7960.	8304.	.489												.001
13. PARTICULATES	$\mu g/m^3$	12.1	12.8		DEP*	DEP	DEP	DEP	DEP	DEP	DEP	DEP	DEP	DEP	DEP	DEP
INTERCEPT					-5.22	-7.59	-7.64	-7.34	-10.9	-9.49	-9.81	-4.64	-4.41	-4.77	7.07	3.65
MULTIPLE CORRELATION COEFFICIENT					.620	.618	.617	.616	.614	.601	.562	.500	.623	.621	.649	.650
STANDARD ERROR OF ESTIMATE					10.8	10.7	10.6	10.5	10.5	10.5	10.8	11.2	10.4	10.4	10.1	10.1

*Dependent Variable

F-ratio is calculated at 3.89 as shown in the appendix, Section B.2.2. This is a statistically significant correlation since any value of F greater than 2.49 is outside the 95 percent confidence interval.

The results of subsequent multiple linear regression iterations dropping the least significant parameter at a time on the basis of the lowest T-value (see appendix) are summarized in Table 3-17 also. Only variables with regression coefficients shown were in that respective iteration. The multiple correlation coefficients (b_i) and intercept (b_o) are the coefficients for the regression equation for predicting particulate concentration ($PART_{est}$), given the observations (X_i) of the n independent variables.

$$PART_{est} = b_o + \sum_{i=1}^{n} (b_i X_i).$$

In all cases the F-ratio (not shown) is significant. The intercept is the predicted particulate concentration if all independent-variable observations are zero. The standard error of the estimate is the standard deviation in $\mu g/m^3$ of the estimated particulate concentration.

Computer plots of particulate concentration as functions of wind speed and max wind speed are shown in the appendix, Section B.2.2. All of these figures show the scatter diagrams of the paired observations. The linear regression line of particulate concentration on the independent variable is also plotted. These plots provide visibility to the scatter of the data and relationship of particulate concentration to the selected variable. In all cases, the variability is quite large. The correlations between particulate loading and maximum wind speed and with maximum speed squared are the most significant of all the parameters and are shown in Figures 3-19 and 3-20 respectively as computer plots. Asterisks on these figures represent the regression line; a number means that number of data points which are superimposed. Maximum wind speed (both the first and second powers) appears to be the most important correlative parameter with particulate loading. This indicates that high particulate readings on the C-b Tract are primarily of the nature of fugitive dust. Solar radiation and precipitation are next in importance in that order. Monthly average soil moisture had little influence, which was unexpected, probably because monthly rather than daily soil moisture values were used since only monthly values were measured.

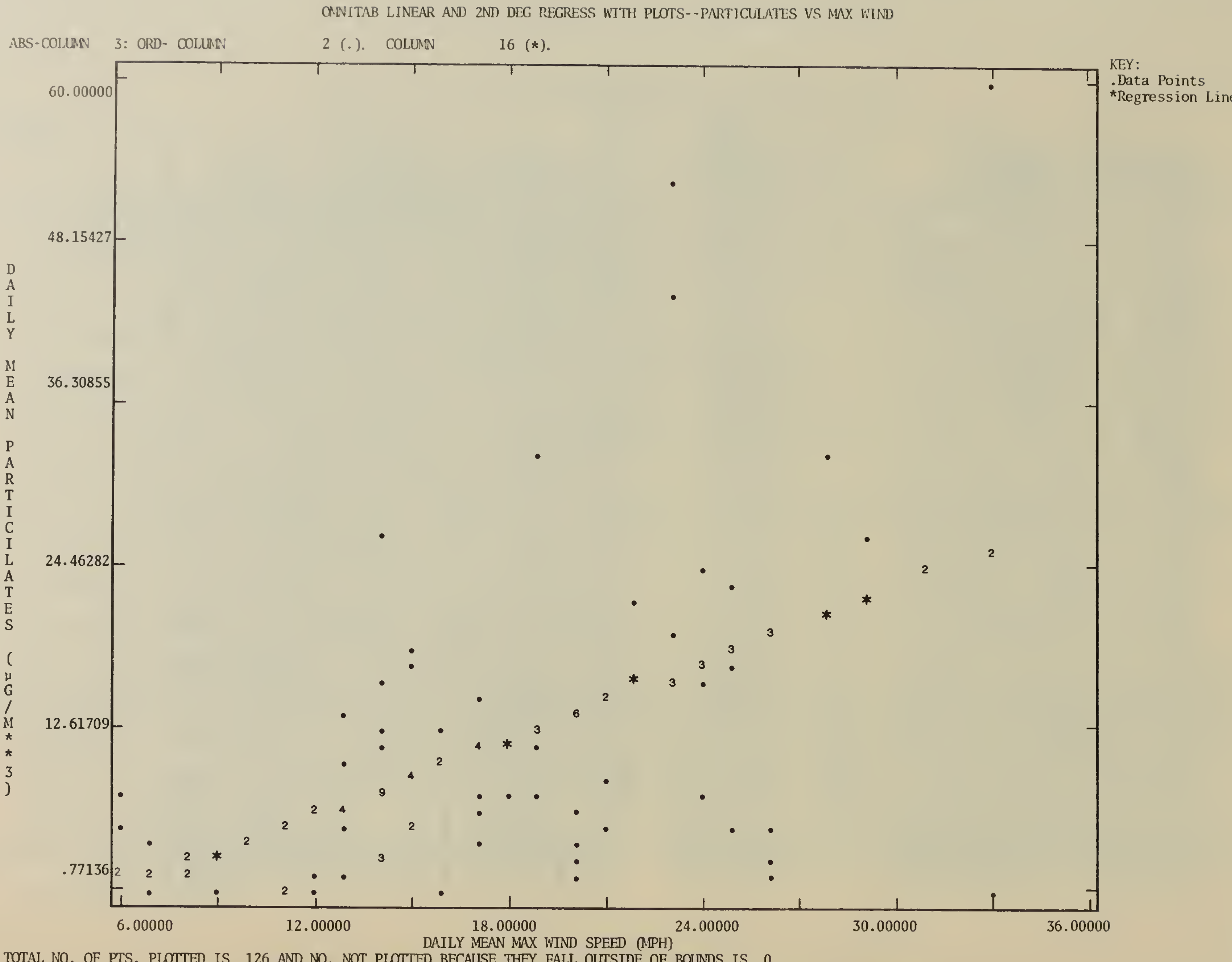


Figure 3-19 COMPUTER PLOT OF PARTICULATES CONCENTRATION AS A FUNCTION OF WIND SPEED

OMNITAB LINEAR AND 2ND DEG REGRESS WITH PLOTS--PARTICULATES VS MAX WIND

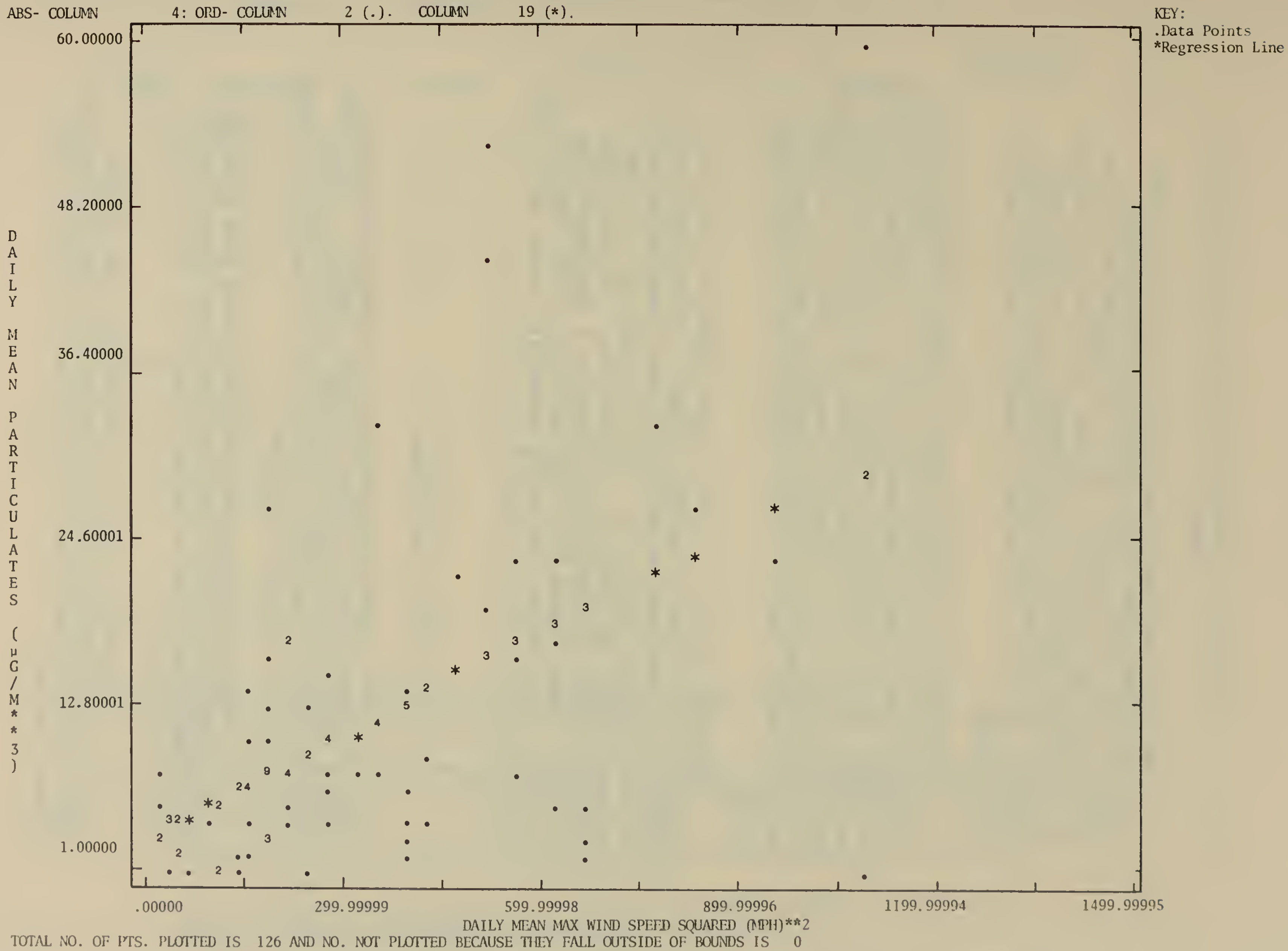


Figure 3-20 COMPUTER PLOT OF PARTICULATES CONCENTRATION AS A FUNCTION OF WIND SPEED SQUARED

3.2.2.5.3 Size Distributions in the Respirable Range

Quarterly sampling of particulates in the respirable range was achieved over eight quarters by utilizing an Andersen sizer on the head of the hi-vol sampler at Station 023. Use of multiple filters allowed the following groupings of aerodynamic diameters to be obtained: 7.0 microns and above, 3.3 to 7.0 microns, 2.0 to 3.3 microns, 1.1 to 2.0 microns, and 0.01 to 1.1 microns. Sampling time per quarter was 24 hours.

Regarding the respirable range for particulates Williamson 1973 points out the following: a) particulates $\geq$ 5 microns are filtered before leaving the trachea; those < 3 microns can escape the upper respiratory defense and enter the lung; b) particles in two sizes are most effectively retained in the lung - 0.5 microns and 0.05 microns; for intermediate ranges (about 0.25 microns) only 20-40 percent are retained in the lung, the rest being exhaled. Thus the sampling at C-b covers the entire respirable range.

Sampling results in terms of mass density of particlates ($\mu g/m^3$) as a function of particle diameter are presented on Table 3-18; associated meteorological conditions during sampling are identified on Table A-12. As noted, winds up to 60 mph occurred during the April 24, 1975 sampling. The particulate cumulative mass distribution is plotted as a function of the arithmetic mean of each size range on Figure 3-21. Inasmuch as the plot is a straight line on log-probability paper the distribution of particulate mass density with particle size is log-normal.

3.2.2.5.4 Conclusions

1) Total suspended particulates were adequately sampled daily at five stations utilizing hi-volume samplers. Size distributions were adequately sampled quarterly utilizing Andersen heads in the hi-vol samplers. The daily hi-vol sampling frequency is adequate and should be continued.

2) Highest concentrations of particulates were obtained in the summer, lowest in winter when snow cover reduced fugitive dust. Four summer peaks occurring in the first year exceeded federal standards.

3) Occurrence in time of concentration peaks between stations correlated well early in the spring; later differences in peaks occurred probably due to differences in vegetative cover between stations.

Table 3-18

SIZE* DISTRIBUTION OF AIRBORNE PARTICULATE MATTER IN THE RESPIRABLE RANGE AT THE C-b TRACT

1st year Quarter	Sampling Date	Size Range** (microns) 7.0 & above	3.3 - 7.0	2.0 - 3.3	1.1 - 2.0	0.01 - 1.1	Total Particulate matter $\mu g/m^3$
1st	November 22, 1974	+	+	+	+	+	
2nd	January 27, 1975	1.77	1.89	6.62	2.13	5.44[1]	17.85
3rd	April 24, 1975	22.06	15.25	6.81	5.31	3.44	52.87[3]
4th	July 25, 1975	5.02	3.43	2.64	1.85	1.58	14.53
	October 4, 1975[2]	3.66	3.05	2.01	0.91	4.08[1]	13.72
	Average	8.13	5.91	4.52	2.55	3.64	24.74
2nd year							
1st	January 22, 1976	2.16	1.69	1.55	1.42	1.01	7.83
2nd	March 17, 1976	4.03	3.29	2.80	2.22	1.32	13.66
3rd	June 15, 1976	5.59	5.12	4.12	3.39	7.80[1]	26.02
4th	September 1, 1976	11.55	6.51	4.89	4.03	2.40	29.38
	Average	5.83	4.15	3.34	2.77	3.13	19.22
2-Yr. Avg. Mass Distribution (%)		31.7	22.9	17.9	12.1	15.4	100.0
Cum. Mass Distribution (%)		100.0	68.3	45.4	27.5	15.4	

* Aerodynamic diameter of the particulate matter.

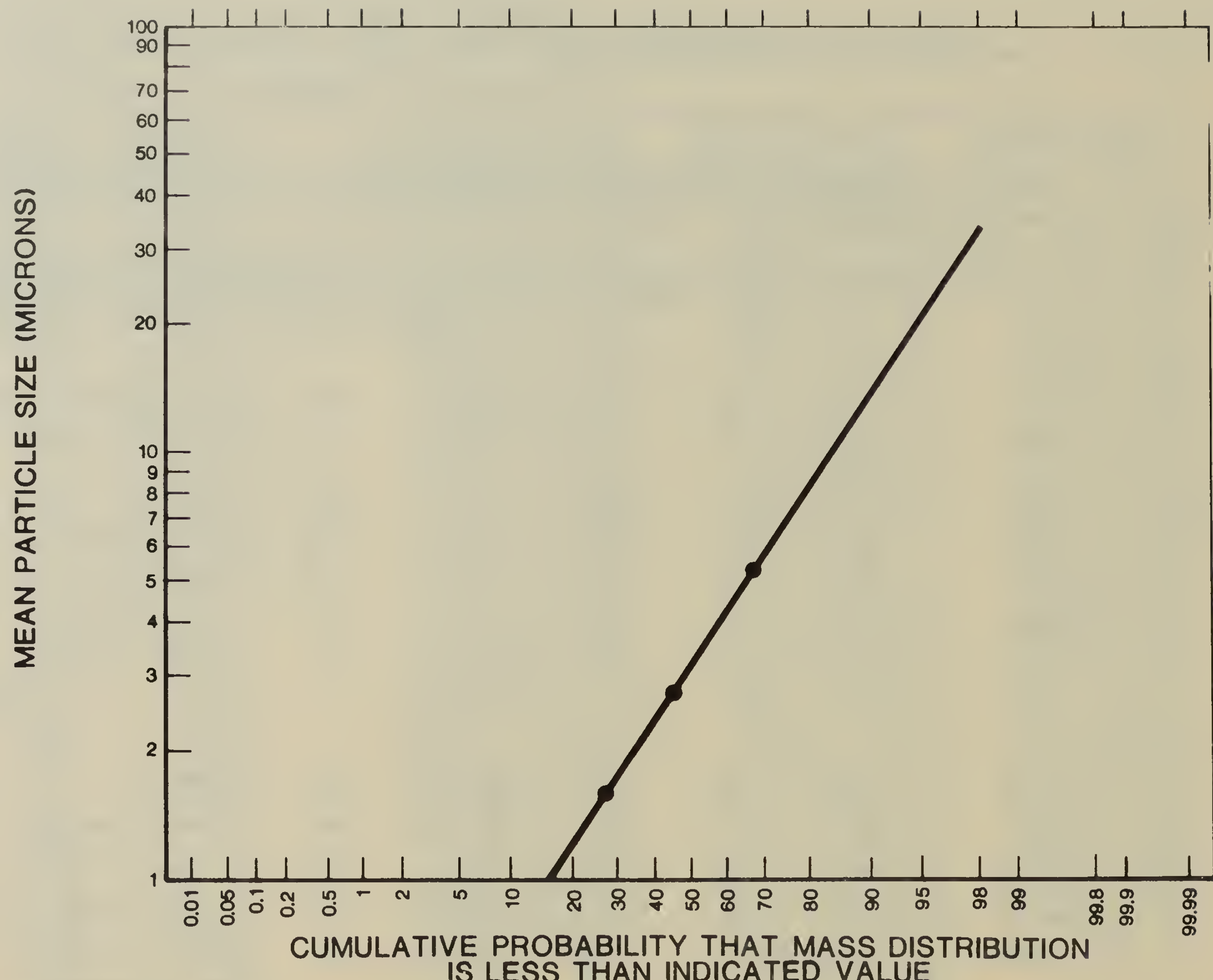
\+ No sample was collected because of the non-availability of the Andersen sizer.

** Numbers in these columns represent the particulate matter expressed as $\mu g/m^3$. The volumes of sampled air were corrected for BP and temperature.

1 Although this represents particulate matter of 0.01 - 1.1 microns aerodynamic diameter collected on the back of the filter (8" x 10"), a couple of particles of much larger diameter were observed. This may have happened due to "particle bouncing phenomenon," a common occurrence in the Andersen sizer due to particle impactor process.

2 An additional sample was collected at the end of the first year because no sample was collected in the first quarter due to non-availability of the Andersen sizer.

3 Although sampling starting date was April 24, 1975, somewhere during the night of April 25, 1975, the wind velocity went up as high as 60 miles per hour. This may have some effect on the increased particulate concentration observed during this sampling.



PARTICULATE CUMULATIVE MASS DISTRIBUTION IN THE RESPIRABLE RANGE AS A FUNCTION OF PARTICLE SIZE (AVERAGE OF 8 QUARTERS; EACH QUARTER IS ONE 24-HOUR AVERAGE)

FIGURE 3-21

4) Particulates concentrations correlated best with wind speed indicating that the nature of particulate loadings at the C-b Tract is primarily fugitive dust.

5) Cumulative particulate mass concentrations in the respirable range are log-normally distributed with particle size.

3.2.3 Ozone Transport Analysis

3.2.3.1 Rationale

During the two-year baseline monitoring program, ozone levels were observed which approached the federal air quality standard of 160 $\mu g/m^3$. Since there were no obvious nearby sources of ozone precursors (hydrocarbons and nitrogen oxides) which would explain the high ozone levels, two studies were undertaken to determine if the ozone might have been transported into the area. One of these examined stratospheric injection of ozone; the other examined long-range transport of ozone or ozone precursors.

3.2.3.2 Objectives

- To determine whether stratospheric injection of ozone could contribute to high ozone concentrations at Tract C-b.

- To determine whether long-range transport of ozone could contribute to high ozone concentrations at Tract C-b.

- To determine whether long-range transport of ozone precursors could contribute to high ozone concentrations at Tract C-b.

3.2.3.3. Methodology

For the long-range transport study, trajectories of air masses were derived from the FOUS Trajectory Forecasts from the National Weather Service. Data from Denver and Alamosa, Colorado and from Lander, Wyoming were interpolated to derive trajectories for air parcels arriving at the monitoring sites. In this same study, attempts were made to establish correlations between ozone events and parameters which included solar radiation, barometric pressure, nitrogen oxides, non-methane hydrocarbons, and carbon monoxide. Increasing carbon monoxide could indicate the influx of an urban air mass, whereas a decrease might mean a dilution of the ambient air by an air mass swept down from the stratosphere during periods of turbulence. Relative humidity and average temperature also were evaluated, as was the diurnal pattern of ozone level on the days when the high levels occurred.

For the stratospheric injection study, the basic approach was to screen the data for ozone events which were abnormal, e.g., nocturnal increases in the ozone concentration. Such an increase indicates that an ozone-containing air mass is moving into the area. This ozone could either be ozone which was formed through classic photochemical reactions at another location earlier in the day, or it could result from stratospheric injection of ozone.

Twelve nocturnal ozone events were observed, and three cases of these were selected for detailed meteorological studies to examine the possibility of stratospheric injection. These investigations consisted of: (1) analysis of the synoptic, or large-scale, meteorological situations during the period associated with the occurrence; (2) two-dimensional cross-sections of the atmospheric structure during the event constructed from sounding data taken in the vicinity of Tract C-b by the National Weather Service; and (3) interpolation of surface air parcel trajectories obtained from the National Weather Service. These investigations provided the paths taken by the air parcels reaching Tract C-b. From these trajectories, it was an easy matter to determine if the air parcels passed over urban areas which are sources of ozone precursors before reaching the Tract.

The three cases chosen for study were:

(a) December 13, 1975, beginning at 2200 MST

(b) February 19, 1976, beginning at 2015 MST

(c) April 22, 1976, beginning at 2300 MST

3.2.3.4 Results and Discussion

The long-range transport study was described in Jones and LaHue 1976, utilizing C-b ozone data collected during the first year. Some 72 high ozone events were chosen for examination during this period.

Of the 72 incidents examined, 26 occurred on days when no diurnal pattern was discernable. Pyranometer readings were as likely to be below the monthly average as above. The same was true for carbon monoxide and non-methane hydrocarbons. In only two cases did the month-high carbon monoxide value occur at the same time as the monthly high for ozone. The instances when nitrogen oxides were above the detection limit had no apparent relationship to the maximum ozone levels. No relationship to temperature or relative humidity could be found. Barometric pressure provided the most promising results. Frontal passages occurred on 19 of the 72 days when high ozone levels occurred. Eighty-eight frontal passages occurred during the year, however, and many did not raise the ozone levels.

Another attempt to understand the ozone levels involved a study of air mass movements to determine where the air had been prior to its arrival at the monitoring sites. One period chosen for such study was May 22, 1975. The high carbon monoxide level for the month occurred on this day. Ozone was normal during the day on May 21, but began to increase that night, reaching a maximum of about 135 $\mu g/m^3$ at 8:00 AM, May 22, at both monitoring sites. These factors indicated an influx of ozone laden air, so it was backtracked by evaluating the estimated path of the air mass. The results are shown in Figure 3-22, where Point A represents the estimated location of the air mass 36 hours earlier, and the line represents its path to the monitoring sites. This air mass crossed largely remote areas, but might have crossed Grand Junction prior to its arrival at the Tract.

The next incident of interest is June 26, 1975, when the maximum hourly average for the year was observed at mid-afternoon at both monitoring sites, 160 $\mu g/m^3$ at 020 and 152 $\mu g/m^3$ at 023. The highest total solar radiation (737 langleys) of the year also occurred on this day, and both sites exhibited a strong diurnal pattern, with lows of about 50 $\mu g/m^3$ in the early morning hours. The estimated path of the air mass is also shown in Figure 3-22, beginning at Point C, which is the estimated location of the air mass 24 hours earlier. It can be seen that this air mass passed through the Salt Lake City vicinity during the night. It is possible that ozone precursors were picked up and formed ozone (aided by the high radiation) the next day. Carbon monoxide levels were below average, however and non-methane hydrocarbons did not vary from the average.

Another incident occurred on March 26, 1975, when high (135 $\mu g/m^3$) ozone levels occurred at both sites. Ozone levels started increasing the previous midnight at both stations and reached a maximum at 9:00 AM. This air mass is estimated to have started 36 hours earlier at Point B in Figure 3-22. It passed near or over Las Vegas prior to its arrival at the Tract.

The reference paper, in evaluating the first year of ozone measurements, arrived at the following conclusions:

(a) The one-hour oxidant standard was approached even though the monitoring sites are in a remote and sparsely inhabited area.

(b) High ozone levels occurred in the late winter to late summer months. The diurnal range of concentration is small in the winter and large in the summer.

(c) No correlation could be found between monthly trends or in daily trends for ozone levels and other parameters such as

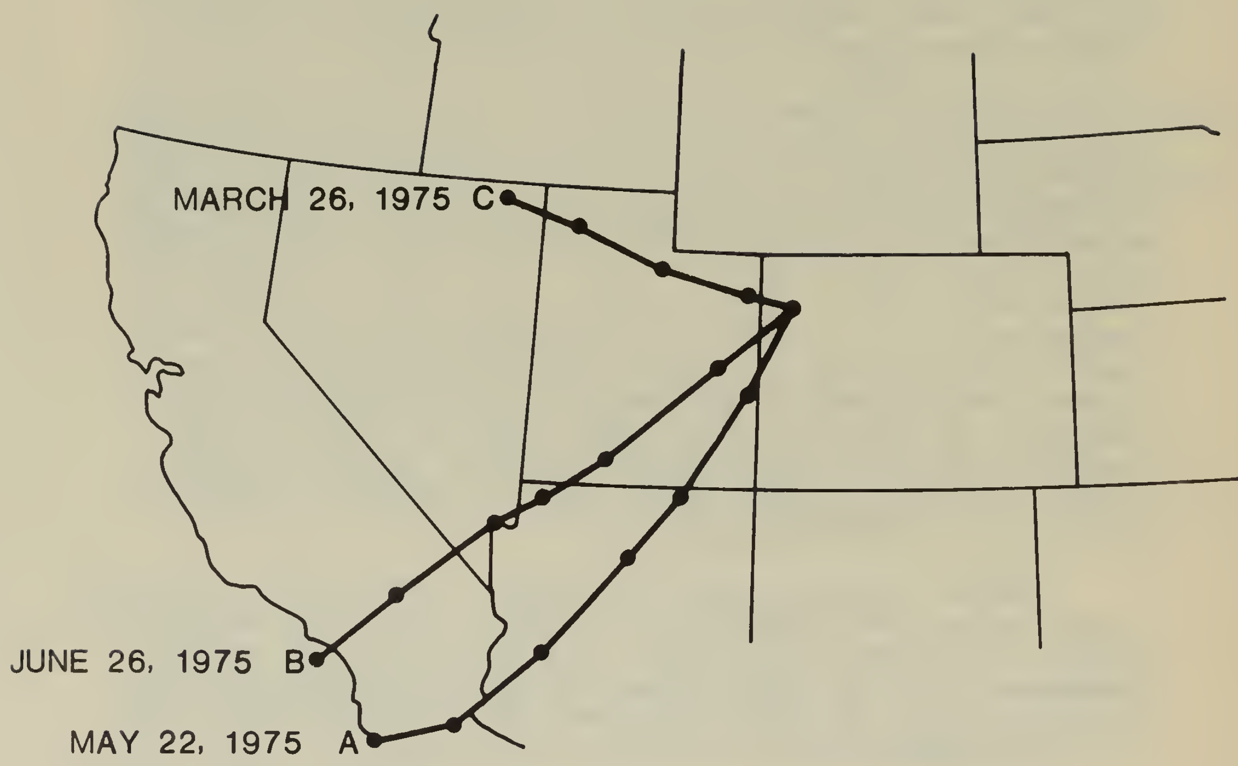


FIGURE 3-22 AIR PARCEL TRAJECTORIES

nitrogen oxides, non-methane hydrocarbons, solar radiation, relative humidity, suspended particulates, or to temperature.

(d) Passage of fronts exhibited a weak correlation with ozone levels.

(e) Based on the diurnal patterns exhibited during high ozone events and air mass movements, it appeared that high ozone levels were a result of an influx of ozone-laden air and not photochemical generation at the site. For two of the instances investigated, the air masses in question might have previously crossed an urban area; nevertheless, the possibility that the ozone was naturally generated could not be precluded.

(f) The maximum hourly values at both sites were achieved as the apparent result of photochemical action near the site. The air mass in question had passed over an urban area the day before, however.

The conclusions reached in this paper should not be construed as providing a definitive explanation as to the chemistry of the ambient-air ozone at Tract C-b. As discussed in the paper there were certain observed phenomena that were not amenable to analyses and interpretations as set forth here. Differences in the valley and plateau ozone concentrations and diurnal trends, seasonal trends, and with few exceptions, a diurnal trend with the maximum occurring during daylight hours are not easily explained by urban transportation. It might be that other factors, including naturally occurring photochemically reactive precursors and stratospheric and urban transportation, also influenced the concentration of ozone in the Tract C-b region.

The analysis of stratospheric injection of ozone at Tract C-b was presented in a paper by David C. Jones and David C. Grossman 1976. Ozone data from the first year and most of the second year were included in this study.

The data sequences on the night of December 13th showed that a strong cold front passed through the Tract C-b region at 2200 hours, accompanied by light snowfall. Thirty-five minutes later, the ozone concentration jumped from 22 parts per billion to 54 parts per billion and remained at this level for another 75 minutes before gradually decreasing. The five-minute averages of Table 3-19 illustrate this phenomenon. The meteorological analysis of this situation showed a strong upper-level low pressure area to the west of the region prior to frontal passage. As the strong cold front passed through the district, its associated surface low tracked very close to the Tract C-b region. Snowfall was general throughout the Utah-Colorado-Wyoming area.

Table 3-19

OZONE CONCENTRATIONS AT STATION 023
December 13, 1975

Time (MST)	Ozone (PPB)	Wind Speed (Miles per Hour)	Wind Direction (Degrees)	Precipitation (Hundredths Inch.)
2120	16	4	152	0
2130	23	5	174	0
2140	11	2	209	0
2150	17	4	243	0
2155	13	6	268	0
2200	14	10	298	0
2205	18	9	307	0
2210	18	9	310	0
2215	20	10	317	0
2220	23	10	302	0
2225	23	10	298	0
2230	22	11	304	0
2235	54	9	301	0
2240	55	10	301	0
2245	54	9	294	1
2250	55	9	304	0
2555	54	9	308	0
2300	54	10	307	1
2310	54	8	299	1

An attempt was made to identify the possible source of the jump in ozone levels on this date. The surface air-parcel trajectory analysis which traces the path of the ozone-bearing air during the previous 24 hours showed that the air did not pass over any urban areas before reaching Tract C-b. However, a cross-sectional analysis of the frontal system as it was structured at 5:00 AM on the morning of December 14th indicated that an intrusion of ozone-bearing stratospheric air into the lowest levels of the atmosphere was possible. The frontal system nearly intersected the tropopause, which is the stable layer of air that separates the troposphere and the overlying stratosphere. The tropopause is normally lowest, about 25,000 feet above sea level, near strong cold fronts. Since air within and behind cold frontal systems descends, much of the ozone-rich stratospheric air that is entrained near the intersection of the frontal layer and the tropopause can subside to levels near the ground at some later time. This downward motion can be intensified by downdrafts associated with widespread snowfall in the region. An isentropic analysis revealed that the downward transport of air from the tropopause to near ground levels was indeed possible in this case. From all indications, then, most of the jump in ozone levels observed at the Tract C-b on the night of December 13, 1975 could probably be attributed to the injection of ozone-rich stratospheric air into the lower levels of the troposphere. This produced an increase in ozone concentration of about 65 $\mu g/m^3$.

The same general synoptic meteorological situation occurred in connection with the nocturnal ozone rise of February 19, 1976. A strong upper-level trough and surface cold frontal passage affected the region during the early evening, at about 2000 hours MST. The surface low pressure system moved very near Tract C-b. Again, surface air parcel trajectories indicated that the air traversed non-urban areas for the 24 hours preceding its arrival at Tract C-b, thus minimizing the possibility of an urban source of the ozone. Cross-sectional analysis indicated that air originating at levels near 25,000 feet could have subsided to near-surface levels by the forced subsidence of air and snowfall-induced down-drafts. This February case was similar to that of the December case in that the cold frontal passage preceded the increase in ozone, and precipitation in the form of snow was beginning to fall at Tract C-b when the ozone levels showed the largest increase. Ozone levels only increased by 10 $\mu g/m^3$ during this event.

The final case study, that of April 22, and 23, 1976, was somewhat different from the previous cases. A cold frontal passage preceded the 12 $\mu g/m^3$ increase in ozone levels by about 20 minutes. However, the ambient air in the region prior to and following the frontal passage was very dry; there was no precipitation. In addition, the upper-level support of this frontal system was fairly weak, as was the surface portion of the front. Cross-sectional analyses of the system indicated that the downward transport of air in connection with this system was limited.

Therefore, there was little support for the stratospheric injection of ozone. In addition, the air parcel trajectory analysis did not indicate that the air parcel passed over an urban area, thereby not acquiring ozone precursors before its arrival at Tract C-b. Therefore, the cause of this nocturnal rise in ozone was in doubt, but the rise, nevertheless, was associated with a cold frontal passage.

In all, 12 instances of nocturnal ozone increases were identified. Although only the three described above were subjected to detailed meteorological studies, frontal passages occurred in eight of the twelve cases. Based on these investigations, it appeared that stratospheric injection of ozone might occasionally have a significant effect on ozone concentration at Tract C-b. In no observed case has it caused the ozone standard to be exceeded, however.

3.2.4 Comparisons of Background Levels with Ambient Standards

During the two years of baseline most background measurements have been at near-zero or low-level values. Occasionally high values for particulates, non-methane hydrocarbons (NMHC), ozone and carbon monoxide have been recorded, including some in excess of the National Ambient Air Quality Standards (Table 2-7). Table 3-20 compares the maximum readings obtained over the 2-year baseline with the appropriate standards. Note that the National-Ambient-Standard annual means for particulates are geometric means computed as the n-th root of the product of n, 24-hour values for the year, where n = 365 less days of missing data.

3.2.4.1 Particulates

As indicated on Table 3-21 readings in excess of the 24-hour standard of 150 $\mu g/m^3$ for particulates have been recorded four times during two years of baseline. The contention is that these high readings are caused by natural fugitive sources. Two lines of reasoning support this conclusion: 1) It was demonstrated in Section 3.2.2 that particulate loadings correlated best with daily-maximum wind speed of all the likely correlation parameters tested. Non-fugitive sources would have exhibited much less dependence on wind speed. 2) Particulate measurements in an urban atmosphere are due preponderantly to non-fugitive sources. Non-fugitive sources are characterized by low ratios of 24-hour peaks to annual means. If a rural source were fugitive, on the other hand, the peak-to-mean ratios would be expected to be much higher. This second point is now investigated further; the first was adequately treated in Section 3.2.3.

Table 3-20 COMPARISONS OF MAXIMUM BACKGROUND LEVELS WITH AMBIENT STANDARDS

Applicable Standard	Constituent	Averaging Time	Standard Limit (μg/m3)	Max. Reading (μg/m3)	Station with Max. Reading	Date of Max. Reading
Colorado Ambient Air Quality Standards	Particulates	Annual	45	11.2	023	'74-'75
		24-hour	150	178(1)	024	11/27/74
National Ambient Air Quality Standards						
Primary	SO_2	Annual	80	1.3	021 & 024	'74-'75
		24-hour	365	112.1	024	8/22/76
Secondary	SO_2	3-hour	1300	79.3	020	9/17/76
Primary	NO_2	Annual	100	5.0	020	'75-'76
Primary	Particulates	Annual	75*	10.7	023	'74-'75
		24-hour	260	178(1)	024	11/27/74
Secondary	Particulates	Annual	60*	10.7	023	'74-'75
		24-hour	150	178(1)	024	11/27/74
Primary	NMHC	3-hour (6-9 a.m.)	160	2596.6 (2)(3)	023	6/27/76
Primary	CO	8-hour	10,000	4501.9	020	6/ 3/75
		1-hour	40,000	4650.9	020	6/ 4/75
Primary	Oxidant	1-hour	160	160.4	020	6/26/75

*Geometric Mean
(1) See also Table 3-21 for additional high readings
(2) See also Table 3-23 for additional high readings
(3) From 2/1/75 to 10/31/76

Table 3-21
PEAK PARTICULATE READINGS DURING BASELINE
($\mu g/m^3$)

(1974-1975)

Station	Nat. Amb. Air Qual. Std.		** Annual Mean		Measured 24-hour Peak*	Peak / Geo. Mean	Date of 24-hr. Peak	Max. 5-Min. Avg. WS on Date of 24-hr. Peak (mph.)
	Annual Geometric Mean	24-Hour	Arithmetic	Geometric				
020	60	150	9.5	Not Calc.	113		11/29/74	8
021			10.2	Not Calc.	125		4/25/75	32
022			8.2	8.1	154	19.0	11/28/74	12
023			11.2	10.7	171	16.0	3/22/75	42
024			7.8	7.8	178	22.8	11/27/74	13
					162	20.8	11/29/74	8

(1975-1976)

Station	Nat. Amb. Air Qual. Std.		** Annual Mean		Measured 24-hour Peak*	Peak / Geo. Mean	Date of 24-hr. Peak	Max. 5-Min. Avg. WS on Date of 24-hr. Peak (mph.)
	Annual Geometric Mean	24-Hour	Arithmetic	Geometric				
020	60	150	8.9	7.6	79.0	10.4	4/2/76	11
021			8.8	7.8	90.0	11.5	4/2/76	14
022			8.0	6.1	60.0	9.8	4/2/76	15
023			7.0	6.0	123.0	20.5	9/21/76	21
024			8.5	7.2	116.0	16.1	4/2/76	15

*Includes all values in excess of standard of 150 $\mu g/m^3$ and/or the 24-hour Peak at each station

**Calculated from all measured 24-hour values

Annual and 24-hour maximum values over six consecutive years for a typical metropolitan-Denver station (21st Street at Broadway) are shown on Table 3-22, and the associated peak (24-hour) to mean (annual) ratios are also calculated. The highest peak-to-mean ratio in six years in a non-fugitive-dust environment was approximately seven with all six values between three and seven. Values on Table 3-21 exceeding the standard at the Tract, on the other hand, were all greater than 16 and were therefore deemed attributable to fugitive sources since these peak-to-mean ratios were much higher than seven. This approach utilizing the comparison with an urban non-fugitive environment was suggested by the EPA.

The EPA has recently issued two position papers (December 21, 1976 and March 30, 1977) regarding high readings of particulates, ozone, and hydrocarbons in rural areas. Both are included in the appendix, Section B.2.5.

Both state that particulates in rural areas of fugitive origin are of much less concern than those of non-fugitive origin. The second reference specifically mentions C-b; one paragraph is very appropriate:

"As outlined in the December 21, 1976, ANPRM, this policy would recognize the differences between violations of the National Ambient Air Quality Standards due to "fugitive dust" in urban and rural areas. New sources that wish to construct in rural areas should be allowed to do so without the need of an emission offset if they meet certain criteria. These include compliance with specified emission limitations and the assurance that the source's emission, plus "non-urban" background and the emissions from other stationary sources in the vicinity of the proposed location, would not cause violations of the NAAQS. "Non-urban" background is defined as the lowest measured annual average particulate concentration measured in the broad area where the new source will be located. This policy, as applied to oil shale development on Colorado Tract C-b, for example, would require (1) compliance with Colorado emission regulations, and (2) the use of 7.8 $\mu g/m^3$ (found in Oil Shale Tract C-b Annual Summary and Trends Report) particulate matter as the background concentration to be superimposed on the air quality diffusion modeling results for the 24-hour and annual predicted concentrations which would then be compared against the applicable ambient air quality standard. Compliance with air quality change limitations in the prevention of significant deterioration regulations also would be required."

Table 3-22 ANNUAL AND PEAK 24-HOUR METRO DENVER PARTICULATES READINGS* AT THE 21st & BROADWAY SITE

($\mu g/m^3$)

Year	Annual Geometric Mean	Peak 24-Hour	Peak-to-Mean
1975	140	397	2.84
1974	170	1180	6.94
1973	140	930	6.64
1972	160	735	4.59
1971	160	888	5.55
1970	175	767	4.38

*Source: EPA, Region VIII, Surveillance Analysis Group

3.2.4.2 Non-Methane Hydrocarbons

Numerous values in excess of the non-methane hydrocarbon "standard" are reported on Tables 3-23a and 3-23b. Although the instrumentation for measurements of hydrocarbons in the C-b trailers is regarded as the best that is commercially available, it is definitely not regarded as highly accurate. Furthermore, the EPA does not, strictly speaking, regard the value for NMHC in Table 2-7 as an absolute standard; its value was set at the same level as that for oxidant in order to assist in keeping oxidant values down.

In Section 3.2.1 an argument was supported that origins of NMHC at the Tract, at least in part, are due to terpenes naturally emitted from sagebrush. Wind directions in Table 3-23 are consistent with general directions of the upland sagebrush community upwind of Station 023; Station 020 in Piceance Creek valley has much less sagebrush upwind.

Section 3.2.3 documented that ozone precursors were also results of long range transport from extra-regional urban centers, or stratospheric storm fronts or both.

The previously referenced EPA policy statements also apply to hydrocarbon control programs. Hydrocarbons are precursors to photochemical oxidant formation and the long-range transport of both has been addressed therein. In essence the statements say that hydrocarbon control programs are deemed to be necessary within a radius of 85 miles of major urban areas and "offset" restrictions are not necessary in rural areas.

3.2.4.3 Carbon Monoxide

The one excessive reading of CO in Table 3-20 was most probably due to exhausts from the temporary power generators initially used in 1974 (for about two or three months) for trailer power until permanent power became available at the Tract.

3.2.4.4 Ozone

Table 3-20 indicated that ozone levels have reached the oxidant standard of 160 $\mu g/m^3$ once at the Tract during the baseline. (It takes two excesses to exceed the standard.) Discussions in Section 3.2.3 of this report support the hypotheses that these high readings could be attributed to either long distance transport from urban sources outside the oil shale region or from stratospheric injection of ozone associated with passages of storm fronts or both.

Table 3-23 PEAK NON-METHANE HYDROCARBON READINGS DURING BASELINE (3-HOUR AVERAGING TIMES - 6-9 am)
(a) FIRST YEAR

Station 020

Month	# of Times	Date	Value (μg/m³)	Wind Direction	Sector	Wind Speed
Feb.	OK					
March	1	3/31	288.6	128.00°	SE	3.00
April	12	4/3	180.0	134.33°	SE	12.33
		4/4	220.0	105.00°	ESE	5.67
		4/7	243.3	232.00°	SW	1.33
		4/9	468.7	150.67°	SSE	5.00
		4/10	478.3	79.33°	E	2.00
		4/11	330.3	282.67°	WNW	5.33
		4/14	353.3	124.33°	SE	5.00
		4/15	370.0	129.33°	SE	6.00
		4/16	358.4	148.33°	SSE	6.33
		4/17	378.1	303.67°	WNW	3.67
		4/18	426.7	295.67°	WNW	4.67
		4/22	707.7	130.00°	SE	6.00
May	OK					
June	OK					
July	OK					
Aug	OK					
Sept.	2	9/1	255.9	112.00°	ESE	4.00
		9/3	319.4	122.00°	ESE	4.00
Oct.	OK					
	15 Total					

Station 023

Month	# of Times	Date	Value (μg/m³)	Wind Direction	Sector	Wind Speed
Feb.	OK					
March	OK					
April	2	4/21	302.2	139.00°	SE	1.00
		4/22	292.2	189.33°	S	17.67
May	OK					
June	18	6/5	355.1	22.00°	NNE	2.00
		6/7	163.3	196.00°	SSW	4.33
		6/8	190.0	267.67°	W	5.67
		6/9	305.3	321.00°	NW	3.00
		6/10	274.4	298.00°	WNW	6.00
		6/11	166.7	67.33°	ENE	3.00
		6/12	203.3	158.00°	SSE	5.00
		6/17	180.0	84.00°	E	5.67
		6/21	193.3	311.00°	NW	3.33
		6/22	160.0	110.67°	ESE	3.33
		6/23	176.7	127.00°	SE	6.67
		6/24	160.0	158.67°	SSE	13.33
		6/25	240.0	185.33°	S	24.00
		6/26	200.0	50.33°	NE	2.67
		6/27	266.6	183.00°	S	16.00
		6/28	203.3	83.00°	E	3.00
		6/29	163.3	147.00°	SSE	9.00
		6/30	290.7	99.00°	E	5.00
July	19	7/1	357.6	142.00°	SE	9.00
		7/2	233.3	130.00°	SE	6.00
		7/3	160.0	146.33°	SSE	4.67
		7/5	163.3	102.00°	ESE	2.00
		7/9	895.6	131.00°	SE	5.00
		7/16	250.0	134.00°	SE	8.33
		7/17	250.0	161.00°	SSE	5.67
		7/18	233.3	172.00°	S	4.00
		7/19	377.9	260.00°	W	1.00
		7/20	265.8	227.00°	SW	2.00
		7/21	203.3	108.33°	ESE	4.00
		7/24	200.0	304.00°	NW	2.67
		7/25	173.3	181.33°	S	2.00
		7/26	220.0	128.67°	SE	2.67
		7/27	183.3	55.33°	NE	2.00
		7/28	552.9	96.00°	E	4.00
		7/29	176.7	179.33°	S	8.33
		7/30	210.0	121.67°	ESE	3.00
		7/31	186.7	193.33°	SSW	2.67
Aug.	13	8/3	520.4	61.00°	ENE	2.00
		8/4	406.7	204.00°	SSW	3.00
		8/6	329.9	82.00°	E	5.00
		8/12	173.3	92.67°	E	2.00
		8/20	233.3	144.67°	SE	2.33
		8/21	193.3	126.33°	SE	3.33
		8/22	287.6	131.00°	SE	3.00
		8/23	236.7	175.67°	S	6.67
		8/24	246.7	209.33°	SSW	13.33
		8/25	323.3	59.00°	ENE	3.00
		8/26	193.3	118.33°	ESE	3.00
		8/27	160.0	119.00°	ESE	6.67
		8/28	210.0	184.33°	S	17.00
Sept.	2	9/16	349.6	139.00°	SE	4.00
		9/26	193.9	154.00°	SSE	3.00
Oct.	14	10/1	468.3	190.00°	S	2.00
		10/2	376.7	128.00°	SE	1.00
		10/3	286.7	103.33°	ESE	2.00
		10/4	240.0	79.00°	E	4.00
		10/5	533.2	85.00°	E	3.00
		10/6	276.7	102.33°	ESE	6.67
		10/7	296.7	180.67°	S	15.33
		10/12	176.7	176.00°	S	18.00
		10/13	343.3	131.67°	SE	5.67
		10/14	399.0	162.00°	SSE	3.00
		10/15	495.3	106.00°	ESE	1.00
		10/29	370.0	96.67°	E	3.33
		10/30	450.3	118.00°	ESE	5.00
		10/31	363.3	293.67°	WNW	7.00
	68 Total					

Summary of High Readings as a Function of Wind Directions:

020:		023:	
E	1	E	9
ESE	3	ESE	10
SE	5	SE	13
SSE	2	SSE	7
SW	1	S	11
WNW	3	SSW	4
		SW	1
		W	2
		WNW	2
		NW	3
		NE	2
		ENE	3
		NNE	1

Table 3-23 PEAK NON-METHANE HYDROCARBON READINGS DURING BASELINE (3-HOUR AVERAGING TIME - 6-9 am)
(b) SECOND YEAR

Station 020							Station 023						
Month	# of Times	Date	Value ($\mu g/m^3$)	Wind Direction	Sector	Wind Speed	Month	# of Times	Date	Value ($\mu g/m^3$)	Wind Direction	Sector	Wind Speed
75							75						
Nov.	Missing Data						Nov.	21	11/1	440.0	190.00°	S	1.33
									11/2	499.4	161.00°	SSE	2.00
									11/3	487.2	114.00°	ESE	1.00
									11/4	474.7	149.00°	SSE	1.00
									11/5	491.7	231.00°	SW	1.00
									11/6	330.0	164.33°	SSE	6.33
									11/7	366.7	192.67°	SSW	11.00
									11/8	460.0	278.67°	W	3.67
									11/9	370.0	330.00°	NNW	2.00
									11/10	400.0	150.00°	SSE	11.67
									11/11	530.0	316.33°	NW	6.33
									11/12	220.0	164.67°	SSE	2.00
									11/13	595.1	123.00°	ESE	3.00
									11/14	253.3	130.00°	SE	1.00
									11/23	180.0	176.00°	S	1.67
									11/24	193.3	121.00°	ESE	2.00
									11/26	193.3	180.33°	S	10.00
									11/27	200.0	115.00°	ESE	5.33
									11/28	190.0	177.67°	S	24.67
									11/29	230.0	286.33°	WNW	4.00
									11/30	270.0	207.33°	SSW	10.67
Dec.	OK						Dec.	12	12/1	260.0	190/33°	SSW	24.33
									12/2	280.3	140.00°	SE	4.00
									12/3	270.0	123.00°	ESE	2.33
									12/4	253.3	109.67°	ESE	4.67
									12/5	286.4	105.00°	ESE	3.00
									12/6	268.7	87.00°	E	3.00
									12/7	263.3	127.67°	SE	2.67
									12/8	277.2	141.00°	SE	3.00
									12/9	260.0	216.33°	SW	0.67
									12/10	243.3	144.67°	SE	6.33
									12/11	270.1	156.00°	SSE	3.00
76							76		12/12	253.3	164.67°	SSE	13.00
Jan.	OK						Jan.	12	1/1	557.8	264.00°	W	4.00
									1/3	213.3	139.67°	SE	3.00
									1/4	213.3	196.67°	SSW	1.67
									1/15	290.0	167.00°	SSE	4.67
									1/16	351.5	200.00°	SSW	1.00
									1/20	381.3	249.00°	WSW	1.00
									1/21	213.3	165.67°	SSE	1.67
									1/22	343.3	128.67°	SE	1.33
									1/23	364.0	141.00°	SE	5.00
									1/24	361.0	269.00°	W	2.00
									1/25	236.7	169.00°	S	3.33
									1/26	223.3	143.67°	SE	1.67
Feb.	OK						Feb.	18	2/10	176.7	199.67°	SSW	10.00
									2/12	373.3	125.67°	SE	4.67
									2/13	553.3	113.33°	ESE	2.67
									2/14	523.3	202.67°	SSW	8.33
									2/15	580.0	159.33°	SSE	4.67
									2/16	627.9	171.00°	S	4.00
									2/17	543.3	270.67°	W	7.33
									2/18	440.0	205.00°	SSW	15.33
									2/19	370.0	181.67°	S	19.67
									2/20	711.3	311.00°	NW	18.00
									2/21	775.2	203.00°	SSW	2.00
									2/22	366.7	94.67°	E	3.67
									2/23	460.0	125.33°	SE	4.67
									2/25	825.3	125.00°	SE	3.00
									2/26	929.6	188.00°	S	6.00
									2/27	353.3	139.33°	SE	2.67
									2/28	480.0	175.67°	S	9.33
									2/29	540.0	186.00°	S	20.00
Mar.	Missing Data						Mar.	27	3/1	396.7	177.00°	S	8.00
									3/2	528.7	274.00°	W	5.00
									3/3	423.3	193.33°	SSW	1.33
									3/4	306.7	290.00°	WNW	10.00
									3/5	363.3	141.00°	SE	2.67

(b) SECOND YEAR (Continued)

Station 020							Station 023						
Month	# of Time	Date	Value (μg/m³)	Wind Direction	Sector	Wind Speed	Month	# of Times	Date	Value (μg/m³)	Wind Direction	Sector	Wind Speed
							Mar.		3/6	406.7	232.00°	SW	0.33
							Cont.		3/7	433.3	131.33°	SE	0.33
									3/8	323.3	143.33°	SE	1.67
									3/10	456.7	117.00°	ESE	2.00
									3/11	506.7	182.00°	S	13.00
									3/13	500.0	91.00°	E	3.67
									3/14	313.3	241.00°	WSW	2.00
									3/15	539.3	153.00°	SSE	1.67
									3/16	516.2	150.00°	SSE	4.00
									3/19	446.7	285.67°	WNW	16.33
									3/20	524.4	288.00°	WNW	11.00
									3/21	400.0	231.67°	SW	10.00
									3/22	366.7	127.67°	SE	3.67
									3/23	290.0	177.67°	S	12.67
									3/24	330.0	190.67°	S	2.67
									3/25	366.7	216.33°	SW	17.33
									3/26	296.7	154.00°	SSE	2.00
									3/27	270.5	126.33°	SE	13.33
									3/28	343.3	127.00°	SE	2.67
									3/29	390.0	282.67°	WNW	4.67
									3/30	250.0	86.33°	E	1.67
									3/31	565.1	163.00°	SSE	4.00
Apr.	OK						Apr.	21	4/1	213.3	141.67°	SE	8.67
									4/3	240.0	147.67°	SSE	0.67
									4/4	586.7	172.00°	S	8.33
									4/9	443.3	199.33°	SSW	15.00
									4/10	540.8	348.00°	NNW	2.00
									4/12	470.0	185.67°	S	17.00
									4/13	323.3	153.33°	SSE	13.67
									4/14	410.0	176.33°	S	4.33
									4/15	333.3	172.67°	S	6.33
									4/16	306.7	175.67°	S	9.33
									4/17	323.3	293.33°	WNW	9.33
									4/18	373.3	96.00°	E	2.00
									4/19	393.3	303.00°	WNW	2.00
									4/21	690.0	149.00°	SSE	7.00
									4/23	1842.1	240.00°	WSW	5.00
									4/24	1116.7	68.33°	ENE	1.00
									4/25	1202.4	155.00°	SSE	9.00
									4/27	1639.3	84.00°	E	3.00
									4/28	2026.7	268.00°	W	3.33
									4/29	1992.6	288.00°	WNW	2.00
									4/30	360.0	117.67°	ESE	4.33
May	OK						May	16	5/1	1816.4	81.00°	E	3.00
									5/2	1369.5	37.00°	NE	3.00
									5/3	1638.7	99.00°	E	4.00
									5/4	1250.0	204.67°	SSW	14.00
									5/5	1644.1	330.00°	NNW	1.00
									5/6	1253.3	264.33°	W	2.33
									5/8	1296.7	247.00°	WSW	2.00
									5/11	1365.9	198.00°	SSW	14.00
									5/12	1346.7	195.67°	SSW	4.00
									5/13	1253.3	82.67°	E	2.00
									5/18	1136.7	182.67°	S	6.33
									5/19	1106.7	137.67°	SE	5.00
									5/20	793.3	183.00°	S	8.67
									5/21	1086.7	129.00°	SE	2.33
									5/22	1226.7	189.00°	S	10.00
									5/24	1336.7	53.67°	NE	2.00
June	OK						June	20	6/4	2143.3	135.00°	SE	10.33
									6/5	2203.3	84.00°	E	4.00
									6/6	2106.7	170.33°	S	9.67
									6/7	2113.3	122.00°	ESE	6.33
									6/8	1950.0	154.67°	SSE	10.00
									6/9	1993.3	175.33°	S	11.33
									6/10	1896.7	173.67°	S	13.33
									6/11	1556.7	197.67°	SSW	20.00
									6/12	2050.0	220.00°	SW	5.00
									6/13	1960.0	223.67°	SW	6.00
									6/19	2148.8	8.00°	N	2.00
									6/20	1616.7	133.33°	SE	10.00
									6/21	1660.0	158.33°	SSE	9.00
									6/23	1833.3	197.67°	SSW	2.67
									6/24	1930.0	163.33°	SSE	2.67
									6/25	2010.0	169.67°	S	7.67
									6/26	2578.3	283.00°	WNW	5.00
									6/27	2596.6	62.00°	ENE	3.00
									6/28	2574.0	255.00°	WSW	2.00
									6/30	1746.7	152.67°	SSE	7.67

(b) SECOND YEAR (Continued)

Station 020							Station 023						
Month	# of Times	Date	Value ($\mu g/m^3$)	Wind Direction	Sector	Wind Speed	Month	# of Times	Date	Value ($\mu g/m^3$)	Wind Direction	Sector	Wind Speed
July	1	7/13	177.4	98.00	E	Missing Data	July	13	7/1	1693.3	179.00^0	S	13.67
									7/2	2423.3	38.67^0	NE	2.33
									7/3	2520.9	51.00^0	NE	3.00
									7/4	2465.1	80.00^0	E	4.00
									7/5	2513.5	62.00^0	ENE	2.00
									7/6	2436.6	123.00^0	ESE	5.00
									7/7	1410.0	102.33^0	ESE	5.33
									7/8	1586.7	145.67^0	SE	6.33
									7/9	1643.3	156.00^0	SSE	5.67
									7/10	1800.0	184.67^0	S	2.67
									7/11	2410.0	182.67^0	S	1.33
									7/12	2450.0	177.00^0	S	9.00
									7/13	1923.3	91.00^0	E	2.67
Aug.	OK						Aug.	3	8/4	187.4	184.00^0	S	17.00
									8/6	1261.9	141.00^0	SE	8.00
									8/11	494.7	137.00^0	SE	9.00
Sept.	3	9/5	162.7	94.00	E	4.00	Sept.	6	9/1	760.0	130.00^0	SE	1.33
		9/6	303.1	97.00	E	4.00			9/2	746.7	130.67^0	SE	3.67
		9/7	452.4	46.00	NE	0.00			9/3	2213.3	71.33^0	ENE	2.00
									9/4	2233.6	89.00^0	E	1.00
									9/5	2236.4	61.00^0	ENE	2.00
									9/6	2048.2	158.00^0	SSE	4.00
Oct.	OK						Oct.	6	10/18	166.3	252.33^0	WSW	2.67
									10/19	223.8	120.00^0	ESE	2.00
									10/20	228.3	210.00^0	SSW	2.00
									10/21	287.5	131.00^0	SE	1.00
									10/28	288.4	132.00^0	SE	1.00
									10/29	298.9	177.00^0	SE	1.00
	4 Total							175 Total				=179	

Summary of High Readings as a Function of Wind Directions:

020:	2nd Year		2 Yr. Total		023:	2nd Year		2 Yr. Total
	E	3	E	4		N	1	1
	NE	1	NE	1		NNE	0	1
			ESE	3		NE	4	6
			SE	4		ENE	5	8
			SSE	3		E	13	22
			SW	1		ESE	14	24
			WNW	3		SE	32	45
						SSE	24	31
						S	31	42
						SSW	17	21
						SW	7	8
						WSW	6	6
						W	7	9
						WNW	9	11
						NW	2	5
						NNW	3	3

3.2.4.5 Other Parameters

No other parameters have indicated readings in excess of air quality ambient standards as seen by examination of Table 3-20.

3.2.4.6 Conclusions

1) Four readings of particulate concentrations in excess of federal ambient standards have been recorded during the two-year baseline. Particulates at the C-b Tract are judged to be primarily fugitive dust. In two recent position papers, the EPA has judged that fugitive dust is relatively unimportant compared to non-fugitive sources and that "offset" requirements do not apply to fugitive sources.

2) Many excesses of the federal standards for non-methane hydrocarbons have been recorded. Hypotheses have been presented and supported to show possible origins due to naturally emitted terpenes from sagebrush and to extra-regional long-distance meteorological transport or both. The referenced EPA position papers state that hydrocarbon controls are deemed to be necessary only within a radius of 85 miles of major urban centers and "offset" restrictions are not necessary in rural areas.

3) The federal oxidant standard was reached once at the Tract but not exceeded.

4) One early excessive CO reading was estimated to be due to temporary power generators.

5) No other parameters have exceeded ambient air quality standards during the baseline.

3.2.5 Side-By-Side SO_2/H_2S Tests

3.2.5.1 Rationale

For both SO_2 and H_2S, the continuous analyzers frequently measured zero pollutant concentrations. During those events when a pollutant was detected, the instrument output normally reached only a few percent of full-scale. Since the basic accuracy of the flame photometric analyzers is ±1 percent of full-scale, a three-month study was undertaken using co-located analyzers to evaluate the agreement between analyzers at very low concentrations.

3.2.5.2 Objectives

- To obtain a measure of the agreement between co-located SO_2 analyzers and a measure of agreement between co-located H_2S analyzers so as to assess "installed" instrument accuracy.

- To obtain an indication of the significance of the air quality data for low concentrations of SO_2 and H_2S.

3.2.5.3 Experimental Design

Two SO_2 analyzers (Meloy Model SA185-2) were operated at Station 021 and two H_2S analyzers (Meloy Model SA185-2) were operated at Station 023. In each station both analyzers were connected to the same air intake manifold and the same hydrogen supply.

3.2.5.4 Methodology

The same basic analyzer was used for both SO_2 and H_2S. In one case, a scrubber selective for H_2S was used on the input; in the other case, an SO_2 selective scrubber was used. To run the three-month side-by-side test, an H_2S scrubber was moved from Station 023 to Station 021, and an SO_2 scrubber was moved from Station 021 to Station 023 for the test period of January, February, and March 1976.

Manufacturer's specifications for the Meloy Model SA185-2 include the following:

Full scale range - 1000 ppb
Minimum detection limit - 5 ppb (13 $\mu g/m^3$ for SO_2, 7 $\mu g/m^3$ for H_2S)
Maximum drift within a 24-hour period - ±1 percent full-scale ≡ 20 ppb range or ±10 ppb
(52 $\mu g/m^3$ SO_2) (28 $\mu g/m^3$ H_2S)
Accuracy = ±1 percent full-scale (≡2 ppb) (52 $\mu g/m^3$ SO_2, 28 $\mu g/m^3$ H_2S)

3.2.5.5 Results and Discussion

Diurnal tables of hourly differences in analyzer readings for each month are presented in the appendix, Section B.2.1. For H_2S, differences were zero for the months of February and March; for SO_2 they were zero for February. From these tables, summary tables have been derived and are presented as Tables 3-24 and 3-25 for SO_2 and H_2S respectively. Tabulated are the

Table 3-24

SUMMARY OF RESULTS OF SIDE-BY-SIDE
SO_2 ANALYZER TEST
($\mu g/m^3$)

Item	Analyzer #1			Analyzer #2			Difference Between Analyzers		
	J	F	M	J	F	M	J	F	M
Monthly average (rounded)	1	0	3	2	0	2			
% hours above detection limit	0.8	0	5.3	0.3	0	3.1			
Total no. paired observations							739	493	605
Total no. of non-zero differences							8	0	63
Mean hourly difference							0.2	0	1.7
Std. dev. of hourly differences							3.1	0	7.8
Maximum hourly difference							50	0	54

Table 3-25

SUMMARY OF RESULTS OF SIDE-BY-SIDE
H_2S ANALYZER TEST
($\mu g/m^3$)

Item	Analyzer #1			Analyzer #2			Difference Between Analyzers		
	J	F	M	J	F	M	J	F	M
Monthly average (rounded)	2	0	0	0	0	0			
% hours above detection limit	19.0	0.1	0.0	0.0	0.0	0.0			
Total no. paired observations							632	492	556
Total no. of non-zero differences							144	1	0
Mean hourly difference							2.2	0.0	0.0
Std. dev. of hourly differences							3.3	0.0	0.0
Maximum hourly difference							19	7	0.0

analyzer monthly averages, percent hours above the minimum detection limit, total number of paired observations, total number of non-zero differences, mean hourly difference, standard deviation of the mean hourly difference, and the maximum hourly difference.

During the three-month test at Station 021, no high levels of SO_2 were recorded. The maximum hourly difference observed was 54 $\mu g/m^3$ on March 22, during a ten-hour period when SO_2 concentrations were above the detection limit. The co-located SO_2 analyzer, however, was above minimum detection limit for eleven hours, and reached a peak of only 19 $\mu g/m^3$ on March 13. The maximum difference of 54 $\mu g/m^3$ is essentially equal to the manufacturer's quoted accuracy of the instrument of 52 $\mu g/m^3$. Because of the very low levels observed, it is difficult to draw definitive conclusions. No significant differences were observed between the two SO_2 analyzers, given the factory specification of ±1 percent drift per day and ±1 percent accuracy.

Ultimately incremental prevention-of-significant deterioration air quality regulations presently at 15 $\mu g/m^3$ for SO_2 would in all probability have to be detectable. The present instrument would not have sufficient accuracy to portray an increment of this level. (Note: As of April 1977 new side-by-side SO_2 tests are underway utilizing an SO_2 instrument with 500 ppb full scale range and 2 ppb minimum detectable limit.) Accuracies of 15 $\mu g/m^3$ or better were not a requirement for baseline measurements, however.

The peak H_2S levels during the three-month test were even lower than the SO_2 levels. The two H_2S analyzers were in Station 023 on the plateau, and only during the month of January were concentrations above the detection limits observed. The results are summarized in Table 3-25. The highest hourly concentration difference observed was 19 $\mu g/m^3$ on January 5 during a two-hour event. The co-located monitor did not indicate a signal above the detection limit during that time. As was the case with SO_2, the apparent H_2S events observed by one analyzer generally were not seen by the other. This could be attributed to the very low levels involved (~1 percent of full-scale), and the inherent drift and accuracy characteristics of the analyzers. The 19 $\mu g/m^3$ is less than 2 percent (28 $\mu g/m^3$) of full-scale so that the accuracy is within manufacturer's specifications.

3.2.5.6 Conclusions

1) Three-month side-by-side SO_2 analyzer tests conducted at Station 021 from January through March 1976 revealed that the maximum hourly difference of 54 $\mu g/m^3$ was approximately equal to the manufacturer's accuracy specification for the instrument.

2) The three-month side-by-side H_2S analyzer tests conducted at Station 023 from January through March 1976 revealed that the maximum hourly difference of 19 $\mu g/m^3$ in instrument readings was within the manufacturer's accuracy specification for the instrument.

3) Instrument readings for SO_2 in any month during the test were above the minimum detectable limit of the instrument a maximum of 5.3 percent of the time for SO_2; for H_2S the maximum was 19 percent in any month.

4) Prevention of significant deterioration regulations for SO_2 require that plant-induced increments of $\leq$ 15 $\mu g/m^3$ be achieved. Although not a requirement for baseline measurements, the present SO_2 instrument could not accurately sense a level near 15 $\mu g/m^3$ since its minimum detectable limit is 13 $\mu g/m^3$.

3.2.6 Trace Elements

Trace elements were studied in two separate programs, each with different specific objectives: 1) trace elements in suspended particulates as determined from spark source mass spectroscopy, and 2) volatile trace elements (selenium, mercury, and arsenic) as determined by special chemical methods. Each is discussed separately.

3.2.6.1 Trace Elements in Suspended Particulates

3.2.6.1.1 Rationale

Once a mine and/or plant is established at Tract C-b, additional sources of suspended particulates may exist and contribute their own particular trace elements to the atmosphere. Without baseline data, this effect would be difficult to evaluate; thus this program was undertaken.

3.2.6.1.2 Objectives

- To define the distribution and variation of trace elements in the suspended particulates at Tract C-b.

- To define the gross alpha and beta radioactivity of the suspended particulates at Tract C-b.

3.2.6.1.3 Experimental Design

Every six days, during the first year of baseline, a special cellulose filter was run in a high volume sampler at Station 023 for twenty-four hours. Cellulose was chosen since it contains very small amounts of the trace elements of interest.

On a quarterly basis, one of these cellulose filters was randomly chosen as a reference, and the other filters were combined into a composite sample. The composite and the single filter were then analyzed for alpha and beta radioactivity, and analyzed for trace elements by spark source mass spectroscopy.

The results of the analysis of the composite sample provided an indication of baseline trace element conditions as a function of season at Tract C-b. The difference between the single filter and the composite on an element-by-element basis provided some indication as to the variation of the trace element composition during a given quarter.

3.2.6.1.4 Methodology

The particulates collected on the special cellulose filters are analyzed by spark source mass spectroscopy (SSMS). This provides a semi-quantitative analysis for some 50 elements. Major constituents such as sodium and magnesium are generally not measured, but simply reported as comprising a major portion of the sample.

For trace elements, the SSMS method is generally accurate within a factor of two to five depending on the element. The detection limit in terms of particulates in the air is approximately 10^{-6} micrograms per cubic meter of air.

Gross alpha and beta radiation and radium 226 radiation were measured by standard radiation counting techniques.

3.2.6.1.5 Results and Discussion

The analytical results for the trace metal study are given in Table 3-26a and 3-26b for both single filters and composite filters respectively. Gross alpha and gross beta radiation are provided in Table 3-27.

Principal conclusions regarding the trace elements in the particulates are the following:

(a) The trace element loadings varied somewhat over the one year period but were usually within an order of magnitude. This was within the analytical variation expected of spark source mass spectrometry.

(b) The single samples did not show unexpected deviations from the composites. The analysis of the composite sample was expected to be the more accurate because of the relatively larger sample size. This may be seen in that more elements were above detection limits in the composites than in the single samples. There were no unexpected variations in the single samples.

(c) The uniformity of the results indicated that these data should provide a representative baseline against which to compare ambient air particulates for the majority of the elements after development of Tract C-b.

(d) The radioactivity, measured as radium 226 and gross alpha and beta, was best characterized as very low, too low in fact for standard counting times to give reasonable counting statistics.

3.2.6.2 Volatile Trace Elements in Air

3.2.6.2.1 Rationale

The rationale for determination of volatile trace elements is similar to that previously mentioned for trace elements in suspended particulates.

3.2.6.2.2 Objectives

The purpose of this program was to establish true baseline concentrations of volatile trace metals namely selenium, mercury, and arsenic in air at the C-b Tract.

Table 3-26

COMPARISON OF AMBIENT ATMOSPHERIC LEVELS OF TRACE ELEMENTS AT TRACT C-b

a. Single Filter

	Single Filter Sample 12/4/74	Single Filter 1/28/75	Single Filter 4/24/75	Single Filter 7/25/75	Single Filter 11/13/75
Uranium	$5x10^{-5}$		$1x10^{-4}$		
Thorium	$3x10^{-5}$		$2x10^{-4}$	$3.3x10^{-4}$	
Bismuth	$3x10^{-5}$	$1x10^{-3}$	$2x10^{-4}$		
Lead	$1x10^{-2}$		$1.2x10^{-2}$	$7.7x10^{-3}$	$8.5x10^{-4}$
Thallium					
Mercury	$<2x10^{-5}$	$<2x10^{-5}$	$<2x10^{-5}$	$<2x10^{-5}$	$<2.2x10^{-5}$
Gold					
Platinum					
Iridium					
Osmium					
Rhenium	Internal Standard		Internal Standard		Internal Standard
Tungsten	$3x10^{-5}$		$2x10^{-6}$		
Tantalum				$3x10^{-5}$	*
Hafnium					
Lutecium					
Ytterbium					$<5x10^{-5}$
Thullium					
Erbium					
Holmium					
Dysprosium					

	Single Filter Sample 12/4/74	Single Filter 1/28/75	Single Filter 4/24/75	Single Filter 7/25/75	Single Filter 11/13/75
Terbium					
Gadolinium					
Europium					
Samarium					$<4x10^{-5}$
Neodymium	$9x10^{-5}$		$1x10^{-4}$	$1.1x10^{-4}$	$<4x10^{-5}$
Praseodymium	$7x10^{-5}$		$2x10^{-4}$	$4x10^{-5}$	
Cerium	$5x10^{-4}$	$1x10^{-4}$	$1.5x10^{-3}$	$4.7x10^{-3}$	
Lanthanum	$2x10^{-4}$	$1x10^{-4}$	$1.7x10^{-3}$	$1.8x10^{-4}$	$2x10^{-5}$
Barium	$2x10^{-3}$	$2x10^{-3}$	$1.5x10^{-2}$	$6.3x10^{-3}$	$4x10^{-5}$
Cesium	$1x10^{-4}$			$1x10^{-4}$	
Iodine		$8x10^{-4}$	$7x10^{-5}$		
Tellurium	$4x10^{-5}$				
Antimony	$2x10^{-4}$	$5x10^{-5}$	$1x10^{-4}$		$1.3x10^{-4}$
Tin	$2x10^{-3}$	$2x10^{-4}$	$2x10^{-4}$	$9x10^{-5}$	$2x10^{-5}$
Indium		Internal Standard	Internal Standard	Internal Standard	Internal Standard
Cadmium	$8x10^{-7}$	$2x10^{-4}$	$1x10^{-4}$	$2x10^{-5}$	
Silver	$1x10^{-4}$		$2x10^{-5}$		$1.5x10^{-4}$
Palladium					
Rhodium					
Radium	$14x10^{-10}$	$8.2x10^{-10}$	$2.9x10^{-9}$	$6.5x10^{-10}$	$1.7x10^{-9}$

	Single Filter Sample 12/4/74	Single Filter 1/28/75	Single Filter 4/24/75	Single Filter 7/25/75	Single Filter 11/13/75
Ruthenium					
Molybdenum	$5x10^{-4}$	$1x10^{-3}$	*	$5.4x10^{-4}$	$4x10^{-5}$
Niobium	$7x10^{-5}$	$2x10^{-5}$	$1.2x10^{-3}$	$1.9x10^{-4}$	
Zirconium	$1x10^{-3}$	$6x10^{-5}$	$3.1x10^{-3}$	$7.7x10^{-4}$	$4x10^{-5}$
Yttrium	$2x10^{-4}$	$2x10^{-4}$	$4x10^{-4}$	$1.3x10^{-4}$	
Strontium	$6x10^{-3}$	$5x10^{-3}$	$1.3x10^{-2}$	$<4.2x10^{-3}$	*
Rubidium	$4x10^{-3}$	$2x10^{-4}$	$6x10^{-4}$	$1.6x10^{-3}$	$3x10^{-5}$
Bromine	$7x10^{-6}$	$7x10^{-4}$	$4x10^{-4}$	$3.3x10^{-4}$	$5x10^{-5}$
Selenium	$8x10^{-5}$	$1x10^{-4}$	$4x10^{-4}$		$2x10^{-5}$
Arsenic	$7x10^{-4}$	$2x10^{-3}$	$3x10^{-4}$	$5x10^{-5}$	$1.2x10^{-4}$
Germanium		$2x10^{-5}$	$4x10^{-5}$		
Gallium	$5x10^{-4}$	$2x10^{-5}$	$1x10^{-4}$	$1.2x10^{-4}$	
Zinc	$2x10^{-2}$	$3x10^{-3}$	*	$5.2x10^{-3}$	$7.2x10^{-4}$
Copper	$2x10^{-2}$	$2x10^{-3}$	$3.1x10^{-3}$	$1.7x10^{-2}$	$7.8x10^{-3}$
Nickel	$3x10^{-4}$	$4x10^{-4}$	$2x10^{-4}$	$3x10^{-5}$	$1.8x10^{-4}$
Cobalt	$4x10^{-4}$		$2x10^{-4}$		*
Iron	$7x10^{-2}$	1.6	≈0.81	≈0.23	Maj.
Manganese	$1x10^{-2}$	$5x10^{-2}$	$1.1x10^{-2}$	$5.2x10^{-3}$	$6.7x10^{-4}$
Chromium	$1x10^{-3}$		$6x10^{-4}$	$3.7x10^{-4}$	$1.4x10^{-3}$

	Single Filter Sample 12/4/74	Single Filter 1/28/75	Single Filter 4/24/74	Single Filter 7/25/75	Single Filter 11/13/75
Vanadium	$2x10^{-3}$	$5x10^{-4}$	$2.1x10^{-3}$	$1.1x10^{-3}$	$4x10^{-4}$
Titanium	$9x10^{-3}$	$1.4x10^{-2}$	0.11	$7.7x10^{-2}$	$1.6x10^{-3}$
Scandium			$1x10^{-4}$		
Calcium	1.1	.5	≈1.7	Maj.	Maj.
Potassium	0.7	.42	0.35	0.18	0.043
Chlorine	$3x10^{-3}$		$2.4x10^{-3}$	$<7.7x10^{-4}$	0.034
Sulphur	$7x10^{-2}$	$1.8x10^{-2}$	0.24	$1.9x10^{-2}$	0.036
Phosphorus	$5x10^{-3}$	2.1	0.14	$6.1x10^{-2}$	0.025
Silicon		1.8	≈2.1	Maj.	Maj.
Aluminum	.2	.12	≈0.48	Maj.	0.045
Magnesium	0.47	3.9	0.18	.091	Maj.
Sodium	$6x10^{-2}$		0.11	$9.1x10^{-2}$	$4.5x10^{-2}$
Fluorine	$4x10^{-3}$	.25	0.016	.022	$6x10^{-3}$
Oxygen		NR	NR	NR	NR
Nitrogen		NR	NR	NR	NR
Carbon		NR	NR	NR	NR
Boron	$8x10^{-3}$	$9x10^{-3}$	NR	NR	NR
Beryllium					
Lithium	$3x10^{-4}$		$2.4x10^{-3}$	$<9.1x10^{-4}$	$1.1x10^{-4}$

NOTE: NR--Not Reported
When no numbers appear, concentration is less than $1x10^{-5}$ μg/m3

* Unable to determine because of blank level

Table 3-26

COMPARISON OF AMBIENT ATMOSPHERIC LEVELS OF TRACE ELEMENTS AT TRACT C-b

b. Composite Filters

	Composite Nov. - Dec. 1974	Composite Jan. - March 1975	Composite April - June 1975	Composite July - Sept. 1975	Composite Oct. - Dec. 1975
Uranium	$7x10^{-5}$	$2x10^{-3}$	$2x10^{-4}$	$<8x10^{-5}$	
Thorium	$6x10^{-5}$		$3x10^{-4}$	$2x10^{-4}$	
Bismuth	$2x10^{-5}$	$1x10^{-4}$	$2x10^{-4}$	$4x10^{-5}$	$4x10^{-5}$
Lead	$3x10^{-3}$	$2x10^{-3}$	$5.8x10^{-3}$	$7.1x10^{-3}$	$1.2x10^{-3}$
Thallium					
Mercury	$<2x10^{-5}$	$<2x10^{-5}$	$<2x10^{-5}$	$<2x10^{-5}$	$<2x10^{-5}$
Gold					
Platinum					
Iridium					
Osmium					
Rhenium		Internal Standard	Internal Standard	$<3x10^{-5}$	Internal Standard
Tungsten	$4x10^{-5}$		*	$2x10^{-5}$	
Tantalum				$3x10^{-5}$	$2x10^{-5}$
Hafnium					
Lutecium					
Ytterbium					$<2x10^{-5}$
Thullium					
Erbium					
Holmium					
Dysprosium					

	Composite Nov. - Dec. 1974	Composite Jan. - March 1975	Composite April - June 1975	Composite July - Sept. 1975	Composite Oct. - Dec. 1975
Terbium					
Gadolinium			$1x10^{-5}$		
Europium			$2x10^{-5}$		
Samarium			$2x10^{-4}$		
Neodymium	$4x10^{-4}$	$1x10^{-4}$	$5x10^{-4}$	$3.1x10^{-4}$	
Praseodymium	$3x10^{-5}$	$2x10^{-5}$	$2x10^{-4}$	$1.2x10^{-4}$	
Cerium	$1x10^{-4}$	$1x10^{-4}$	$4x10^{-3}$	$4.7x10^{-4}$	$2x10^{-5}$
Lanthanum	$9x10^{-5}$	$5x10^{-5}$	$1x10^{-3}$	$2.2x10^{-4}$	$3x10^{-5}$
Barium	$1x10^{-3}$	$1x10^{-3}$	$2.9x10^{-2}$	$2.4x10^{-3}$	$2.7x10^{-4}$
Cesium	$7x10^{-5}$		$1x10^{-4}$	$5x10^{-5}$	
Iodine			$8x10^{-5}$		
Tellurium					
Antimony	$5x10^{-5}$	$8x10^{-5}$	$8x10^{-5}$		
Tin	$6x10^{-4}$	$2x10^{-4}$	$2x10^{-4}$	$1.3x10^{-4}$	$4x10^{-5}$
Indium		Internal Standard	Internal Standard	Internal Standard	Internal Standard
Cadmium			$2x10^{-4}$	$6x10^{-5}$	$2x10^{-5}$
Silver	$6x10^{-4}$	$2x10^{-5}$	$2x10^{-5}$	$3x10^{-5}$	
Palladium					
Rhodium					
Radium	$6.7x10^{-10}$	$6.7x10^{-10}$	$9.1x10^{-1}$.	$2.4x10^{-11}$	0.0

	Composite Nov. - Dec. 1974	Composite Jan. - March 1975	Composite April - June 1975	Composite July - Sept. 1975	Composite Oct. - Dec. 1975
Ruthenium					
Molybdenum	$2x10^{-4}$		*	$9x10^{-5}$	$4x10^{-5}$
Niobium	$6x10^{-5}$		$2x10^{-3}$	$1x10^{-4}$	$2x10^{-5}$
Zirconium	$3x10^{-4}$		$3.8x10^{-3}$	$8.1x10^{-4}$	$1.3x10^{-4}$
Yttrium	$1x10^{-4}$	$1x10^{-4}$	$5x10^{-4}$	$1.6x10^{-4}$	
Strontium	$3x10^{-3}$	$2x10^{-4}$	$1.2x10^{-2}$	$1.9x10^{-3}$	
Rubidium	$2x10^{-3}$	$9x10^{-4}$	$5x10^{-4}$	$3.3x10^{-4}$	$1.5x10^{-4}$
Bromine		$1x10^{-4}$	$2x10^{-5}$	$2x10^{-4}$	
Selenium	$8x10^{-7}$	$6x10^{-5}$	$4x10^{-5}$	$5x10^{-5}$	
Arsenic	$1x10^{-4}$	$1x10^{-3}$	$3x10^{-4}$	$3.6x10^{-4}$	$2.9x10^{-4}$
Germanium	$3x10^{-5}$	$3x10^{-5}$	$4x10^{-5}$		
Gallium	$1x10^{-4}$	$1x10^{-5}$	$1x10^{-4}$	$6x10^{-5}$	
Zinc	$1x10^{-2}$	$9x10^{-3}$	*	$5.5x10^{-3}$	$2.9x10^{-3}$
Copper	$9x10^{-3}$	$6x10^{-2}$	$1.3x10^{-2}$	$1.2x10^{-2}$	$6.8x10^{-3}$
Nickel	$4x10^{-4}$	$3x10^{-4}$	*	$1.3x10^{-4}$	$2.3x10^{-4}$
Cobalt	$3x10^{-4}$		$3x10^{-4}$		*
Iron	$3x10^{-2}$	2.6	0.81	=0.31	Maj.
Manganese	$3x10^{-3}$	$7x10^{-2}$	$8.1x10^{-3}$	$7.4x10^{-3}$	$1.6x10^{-3}$
Chromium	$7x10^{-4}$		$4.3x10^{-3}$	$<7.1x10^{-4}$	$6x10^{-5}$

	Composite Nov. - Dec. 1974	Composite Jan. - March 1975	Composite April - June 1975	Composite July - Sept. 1975	Composite Oct. - Dec. 1975
Vanadium	$4x10^{-4}$	$2x10^{-4}$	$9x10^{-4}$	$1.1x10^{-3}$	$4.1x10^{-4}$
Titanium	$4x10^{-3}$	$6x10^{-3}$	$9.6x10^{-2}$	$3.8x10^{-2}$	$2.9x10^{-3}$
Scandium			$2x10^{-4}$	$6x10^{-5}$	$4x10^{-5}$
Calcium	.3	.44	1.2	Maj.	$4.1x10^{-2}$
Potassium	.1	.26	0.20	0.22	Maj.
Chlorine	$1x10^{-3}$		*	$<1.1x10^{-3}$	$1.7x10^{-3}$
Sulfur	$7x10^{-3}$	$6x10^{-2}$	$8.5x10^{-2}$	$3.8x10^{-2}$	$1.6x10^{-2}$
Phosphorus	$3x10^{-3}$	$4.2x10^{-2}$	$6.5x10^{-2}$	$3.1x10^{-2}$	$8.8x10^{-2}$
Silicon		.42	1.2	Maj.	Maj.
Aluminum	.1 .	$2x10^{-2}$	0.31	Maj.	Maj.
Magnesium	.2	3.6	0.13	0.24	Maj.
Sodium	$5x10^{-2}$	4.2	0.14	$9x10^{-3}$	Maj.
Fluorine	$1x10^{-2}$		*	$2x10^{-2}$	$4.5x10^{-2}$
Oxygen		NR	NR	NR	NR
Nitrogen		NR	NR	NR	NR
Carbon		NR	NR	NR	NR
Boron	$2x10^{-2}$		NR	NR	NR
Beryllium			$3x10^{-5}$		
Lithium	$1x10^{-4}$		$3.1x10^{-3}$	$<1x10^{-3}$	$6x10^{-5}$

NOTE: NR--Not reported.
When no number appears, concentration is less than $1x10^{-5}$ $\mu g/m^3$.

*- Unable to determine because of blank level.

Table 3-27

GROSS RADIOACTIVITY (pci/m^3)

Date of Sample Collection	Gross Alpha ± Precision[1]	Gross Beta ± Precision[1]
Composite of Samples November - December 1974	$6.5 \times 10^{-4} \pm 2.7 \times 10^{-4}$ [3]	$11.4 \times 10^{-2} \pm 0.4 \times 10^{-2}$ [2]
Single Day Sample 12/4/74	$13.0 \times 10^{-4} \pm 8.0 \times 10^{-4}$	$13.2 \times 10^{-2} \pm 0.8 \times 10^{-2}$
Composite of Samples January - March 1975	$6.3 \times 10^{-4} \pm 4.1 \times 10^{-4}$ [4]	$7.1 \times 10^{-2} \pm 0.1 \times 10^{-2}$ [2]
Single Day Sample 1/28/75	$3.4 \times 10^{-4} \pm 1.3 \times 10^{-4}$	$19.6 \times 10^{-2} \pm 4.2 \times 10^{-2}$
Composite of Samples April - June 1975	$6.3 \times 10^{-4} \pm 1.1 \times 10^{-4}$	$3.1 \times 10^{-2} \pm 0.09 \times 10^{-2}$
Single Day Sample 4/24/75	$19.0 \times 10^{-4} \pm 6.0 \times 10^{-4}$	$5.0 \times 10^{-2} \pm 0.4 \times 10^{-2}$
Composite of Samples July - September 1975	$4.3 \times 10^{-4} \pm 0.75 \times 10^{-4}$	$2.3 \times 10^{-2} \pm 0.07 \times 10^{-2}$
Single Day Sample 7/25/75	$3.5 \times 10^{-4} \pm 2.3 \times 10^{-4}$	$5.5 \times 10^{-2} \pm 0.35 \times 10^{-2}$
Composite of Samples October - December 1975	$20 \times 10^{-4} \pm 1.8 \times 10^{-4}$	$2.7 \times 10^{-2} \pm 0.045 \times 10^{-2}$
Single Day Sample 11/13/75	$5.6 \times 10^{-4} \pm 2.0 \times 10^{-4}$	$1.8 \times 10^{-2} \pm 0.6 \times 10^{-2}$

(1) Variability of radioactivity disintegration process (counting error) at the 95 percent confidence level, 1.96 α

(2) Blank Gross Beta 0.004 ± 0.004 pci/cm^2 (420 cm^2/filter)

(3) Blank Gross Alpha 0.0004 ± 0.0004 pci/cm^2 (420 cm^2/filter)

(4) Blank Gross Alpha 0.0007 ± 0.0006 pci/cm^2 (420 cm^2/filter)

3.2.6.2.3 Experimental Design

Each quarter air samples for selenium, mercury, and arsenic were collected and reported. The program covered a span of two years, except for selenium. Selenium sampling was discontinued after the first year because only very low concentrations were measured. Data reported include concentrations of selenium (as oxide), arsenic (as arsine and particulate arsenic), and mercury (as metallic and organic mercury).

3.2.6.2.4 Methodology

A summary of the sampling methodologies and analytical procedures is given in Table 3-28; further details on methodology and quality assurance are presented in the appendix, Section A.6.

3.2.6.2.5 Results and Discussion

Results of the selenium sampling program are given on Table 3-29. Mean concentration over the four sampling quarters was found to be 0.23 $\mu g/m^3$ by a method whose minimum detectable sensitivity was 0.05 $\mu g/m^3$.

Results of the mercury sampling program are presented on Table 3-30. Only metallic mercury was determined the first year; its mean concentration was 0.0108 $\mu g/m^3$. The second year both organic and metallic mercury were determined; mean concentrations of organic, metallic and total mercury were 0.6995, 0.0005, and 0.7000 $\mu g/m^3$.

Results of the arsenic sampling program are presented in Table 3-31. Particulate arsenic was sampled only in the second year with a mean concentration of 0.0022 $\mu g/m^3$. The arsine mean concentration for the second year of sampling was below the detection limit of the method. The reader should take special note that the sampling technique for arsine was changed after the first year of sampling (See appendix, Section A.6). High values reported for the first year were inaccurate and due to shortcomings of the method. Indeed, there is no generally accepted accurate method for arsine sampling at this time; it is definitely in the R and D realm of state of the art.

In summary, consideration of cumulative analytical data indicated (a) selenium concentrations at the C-b Tract were very low in the air, (b) particulate arsenic levels were also low, (c) earlier high levels of arsine observed were probably due to shortcomings in the analytical method used and/or due to interferences, (d) second year sampling indicated arsine to be below the minimum sensitivity of the method, (e) metallic mercury

Table 3-28

SUMMARY OF SAMPLING METHODOLOGIES AND ANALYTICAL PROCEDURES USED FOR DETERMINING VOLATILE TRACE METALS IN AIR AT THE C-b TRACT

Element	Analytical Basis
Selenium*	Doubly distilled water was used to collect selenium oxides. Selenium concentration was determined using the catalytic method. The method is based on the catalytic effect of selenium in the reduction of methylene blue by sodium sulfide. Sensitivity of the method: 0.05 µg
Total Mercury	An air sample for elemental as well as organic mercury compounds was collected, simultaneously, using a cartridge that fits tightly at the bottom of a high volume sampler. The cartridge had four silver screens to collect elemental mercury and two charcoal compartments for organic mercury. The analytical quantification was achieved by heating the silver screens to 350^0C and feeding the mercury vapors into a silica tube placed in the path of a mercury hollow cathode and recording the signal using an atomic absorption spectrometer. Organic mercury from charcoal was extracted using an acid solution, in which organic mercury was determined by flameless atomic absorption technique. Sensitivity of the method: 0.0001 µg
Elemental Mercury	(same as Total Mercury)
Organic Mercury	(same as Total Mercury)
Total Arsenic	Summation of arsine and particulate arsenic.
Arsine	Airborne arsine was trapped into a silver diethyldithiocarbamate solution. The color intensity was measured at 540 nm using Spectronic 20. Sensitivity: 0.5 µg
Particulate Arsenic	High volume sampling was performed. Particulate arsenic was extracted from the filter using a mixture of acids. The evolved arsine from such an acidic solution was reacted with a mercuric bromide impregnated filter paper. The intensity of the color was visually compared with standards. Sensitivity: 0.05 µg. Sampling time: 24 hours

*Concentration expressed as selenium dioxide.

Table 3-29

DETERMINATION OF SELENIUM** IN AIR AT THE C-b TRACT

Quarter	Sampling* Date[1]	Total Volume of Air Sampled (liters)+	Concentrations $\mu g/m^3$
1st	November 22, 1974	225.90	0.37
2nd	January 27, 1975	249.99	0.00++
3rd	April 24, 1975	384.03	0.38
4th	July 25, 1975	144.5	0.16

MEAN CONCENTRATION 0.23 $\mu g/m^3$

Minimum Detection Limit 0.05 $\mu g/m^3$

* Samples were collected at the top of Trailer No. 023.
** Selenium concentrations are expressed as selenium dioxide.
\+ Measured volumes were corrected for BP and temperature.
\++ Heavy rain and snow fall were recorded on the sampling day.
1 Because of very low selenium concentrations recorded in the first year of this program its monitoring in the second year was suspended.

Table 3-30

DETERMINATION OF METALLIC AND ORGANIC MERCURY++ IN AIR AT THE C-b TRACT

1st year Quarter	Sampling* Date	Total Volume of Air Sample (liters)**	Total Mercury[1] ($\mu g/m^3$)	Metallic Mercury ($\mu g/m^3$)	Organic Mercury ($\mu g/m^3$)
1st	November 22, 1974	149,648.00	ND	0.0350	ND
2nd	January 27, 1975	109,334.49	ND	<0.0001+	ND
3rd	April 24, 1975	175,868.79	ND	0.0055	ND
4th	July 25, 1975	131,901.59	ND	0.0027	ND

MEAN CONCENTRATION Metallic Mercury - 0.0108 $\mu g/m^3$

2nd year					
1st	January 22, 1976	86,098.64	0.9521	0.0001	0.9524
2nd	March 17, 1976	149,956.65	1.6873	0.0013	1.6860
3rd	June 15, 1976	142,848.52	0.0004	0.0004	<0.0001
4th	September 1, 1976	174,590.00	0.1600	<0.0001	0.1600

MEAN CONCENTRATION Total Mercury - 0.7000 $\mu g/m^3$
Metallic Mercury - 0.0005 $\mu g/m^3$
Organic Mercury - 0.6995 $\mu g/m^3$

* All samples were collected at the top of the Trailer No. 023.
** Measured volumes were corrected for BP and temperature.
\+ Metallic mercury concentration below the detection limit of the method was recorded. Heavy rain and snow fall were recorded on the sampling day.
++ All collected samples were analyzed by Commercial Testing Laboratory, Denver, Colorado.
ND Not determined.
[1] Total mercury is the summation of metallic mercury and organic mercury concentrations.

Table 3-31

DETERMINATION OF TOTAL ARSENIC** IN AIR AT THE C-b TRACT

1st year Quarter	Sampling* Date	Total Volume of Air Sampled for Arsine[1] (liters)	Total Volume of Air Sampled for Particulate Arsenic (liters)	Total Volume of Air Sampled (liters)+	μg/m³ Total Arsenic**	Particulate Arsenic	Arsine
1st	November 22, 1974	112.96	----	112.96	ND	ND	7.96
2nd	January 27, 1975	187.44	----	187.44	ND	ND	<0.5++
3rd	April 24, 1975	112.95	----	112.95	ND	ND	9.74
4th	July 25, 1975	82.20	----	82.20	ND	ND	7.83
2nd year							
1st	January 22, 1976	94.68	1,518,466.80	1,518,561.48	----	<0.0003	<0.5
2nd	March 17, 1976	89.99	1,503,362.81	1,503,452.80	0.0003	0.0003	<0.5
3rd	June 15, 1976	88.52	1,391,222.70	1,391,311.22	0.0016	0.0016	<0.5
4th	September 1, 1976	90.32	1,442,841.00	1,442,850.32	0.007	0.007	<0.5

MEAN CONCENTRATION - 1st Year - Arsine (AsH_3) = 6.38 μg/m³ (See Appendix A.6 for explanations)

MEAN CONCENTRATION - 2nd Year - Arsine = below the detection limit of the method
Particulate Arsenic = 0.0022 μg/m³
Total Arsenic = 0.0022 μg/m³

* All samples were collected at the top of the Trailer No. 023.
** Includes gaseous arsine (AsH_3) and particulate arsenic.
\+ Measured volumes were corrected for BP and temperature.
++ Heavy rain and snow fall were recorded on the sampling day.
ND Not determined.
1 Addition of this volume to the particulate arsenic volume is equal to the total volume of air sampled.

concentrations were low, (f) organic mercury levels were within acceptable limits.

3.2.7 Visibility

3.2.7.1 Rationale

The documentation of visibility in the Piceance Creek basin area was a study conducted by Dames & Moore jointly for the Rio Blanco Oil Shale and C-b Shale Oil Projects. Initiated in September 1975 this one-year study was one of many environmental programs conducted to satisfy general requirements of the Federal Oil Shale Lease Environmental Stipulations.

Visibility studies are an integral part of any air quality monitoring program. Visibility measurements, though not yet capable of defining or measuring levels of specific atmospheric pollutants, are none-the-less good general indicators of the purity of air. Visibility is also probably the most frequently used layman tool for defining air quality and the only parameter of air quality measurements which is easily understood or recognized by the general public.

3.2.7.2 Objectives

The objectives of this visibility program were 1) to document the baseline visibility in the area of the Piceance Creek basin, 2) to identify trends or variations in visibility which might be evident during a year-long monitoring program, and 3) to correlate visibility with parameters such as particulates, wind speed, etc.

Visibility measurements were obtained between September 25, 1975 and September 22, 1976. Approximately 1550 measurements were obtained and used in the statistical analysis of visual range during this year-long study.

3.2.7.3 Experimental Design

Site and View Description - The collection of visibility data in the Piceance Creek basin area was accomplished from a point approximately eight miles southwest of Piceance Creek on a ridge between Hunter Creek and Dry Gulch. More precisely, the exact location of the photographic site was 39°46'11"N, 108°19'44"W, in:

Township	Range	Section	Description
3S	97W	19	SW/4 SW/4

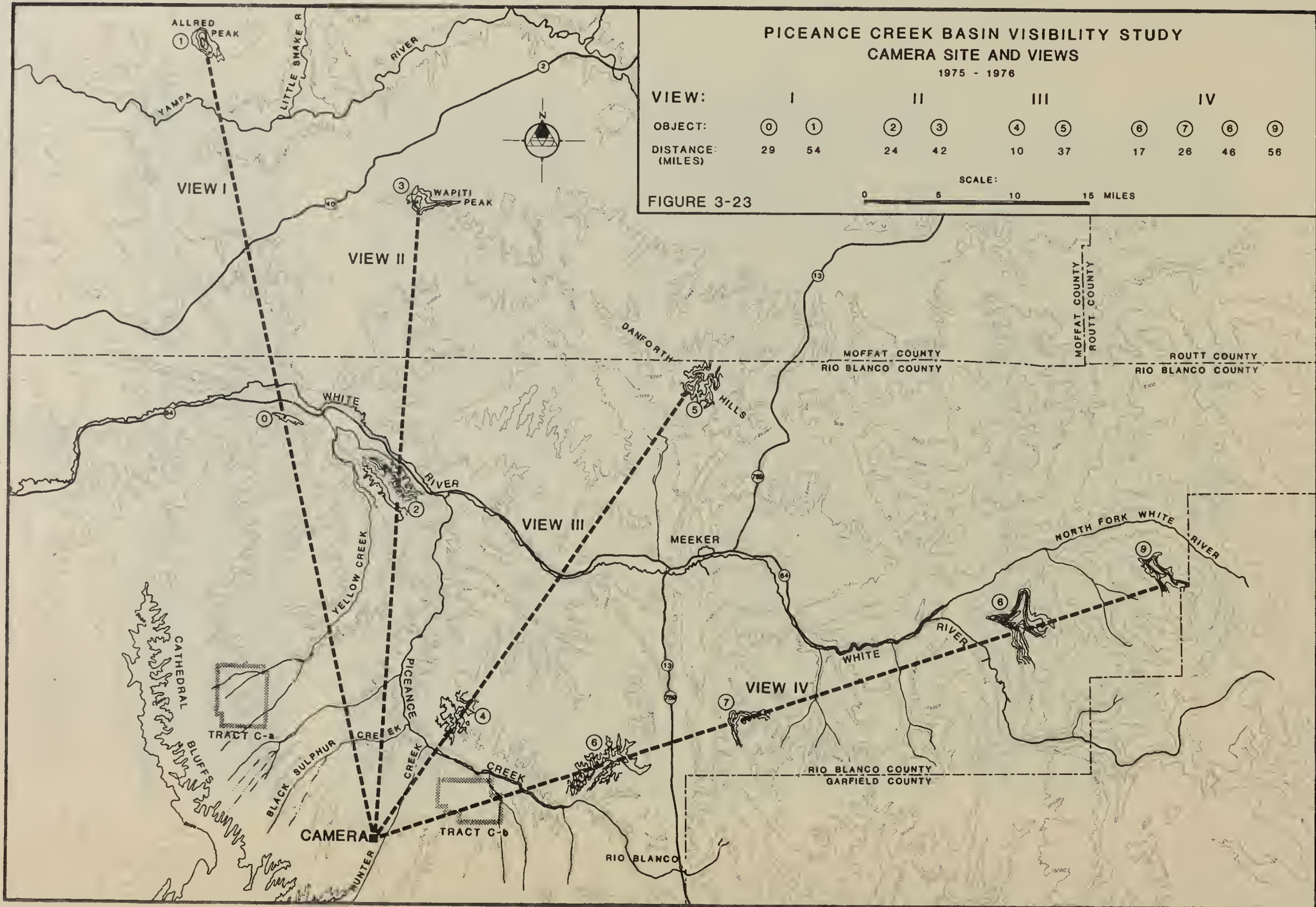
This location was chosen for its proximity to Tract C-a, leased by Rio Blanco Oil Shale Project, and Tract C-b, leased by C-b Shale Oil Project. Additionally, this location has greater accessibility than other prospective sites and enabled visual range measurements to be made along the Piceance Creek basin. During the year long study, no days occurred in which the site was inaccessible to the photographers; however, on several occasions snowmobiles were required to reach the site.

Data were collected by photographing several objects, such as mountains or ridges, in each of four views which scan the horizon from the north-northwest to the east-northeast. Several views were chosen to enhance the probability of detecting variations in visibility which might occur. The use of at least two objects in each view enabled the calculation of a visual range under a variety of visibility conditions. If inclement weather or other restrictions to visibility obscured the most distant object, visual range measurements could often be made with a less distant object. The number of objects in a view had no effect on the accuracy of visual range measurements; the minimum calculable visual range, however, was dictated by the availability of suitable objects near the camera site. It also would have been desirable to incorporate additional views and objects describing a larger portion of the horizon; however, the geographic nature of the area prohibited the use of additional views.

The location of the views used in this study and their orientation to Piceance Creek and Tracts C-a and C-b is shown on Figure 3-23, north being represented by the "N" in the upper right hand corner. Profiles of the terrain along each view path are illustrated in Figure 3-24. The objects being photographed are identified by number. It should be noted that the vertical scale in these profiles in Figure 3-24 is greatly exaggerated, approximately twenty-six times greater than the horizontal scale. Nevertheless, this perspective provides a good grasp of the relative path lengths along the line of sight and the relative distances of each object from the camera.

<u>Measurement Frequency</u> - Visual range measurements were made by photographic photometry every sixth day from September 1975 to September 1976 at the nominal hours of 0830, 0930, 1030, 1130, 1300, 1400, and 1500 MST. Of a planned 1732 measurements, 1548 were obtained for an 89 percent recovery.

<u>Data Reporting</u> - Visual range was reported as daily averages, monthly averages, seasonal averages, and annual averages both by


PICEANCE CREEK BASIN VISIBILITY STUDY
CAMERA SITE AND VIEWS
1975 - 1976
VIEW: I II III IV
OBJECT: 0 1 2 3 4 5 6 7 6 9
DISTANCE: (MILES) 29 54 24 42 10 37 17 26 46 56
SCALE:
0 5 10 15 MILES
FIGURE 3-23
ALLRED PEAK
YAMPA
LITTLE SNAKE R
RIVER
WAPITI PEAK
VIEW I
VIEW II
VIEW III
VIEW IV
DANFORTH HILLS
MOFFAT COUNTY
RIO BLANCO COUNTY
MOFFAT COUNTY
ROUTT COUNTY
ROUTT COUNTY
RIO BLANCO COUNTY
WHITE
RIVER
MEEKER
NORTH FORK WHITE RIVER
WHITE
RIVER
YELLOW CREEK
PICEANCE
CREEK
CREEK
BLACK SULPHUR CREEK
CATHEDRAL BLUFFS
TRACT C-a
TRACT C-b
CAMERA
HUNTER
RIO BLANCO
RIO BLANCO COUNTY
GARFIELD COUNTY

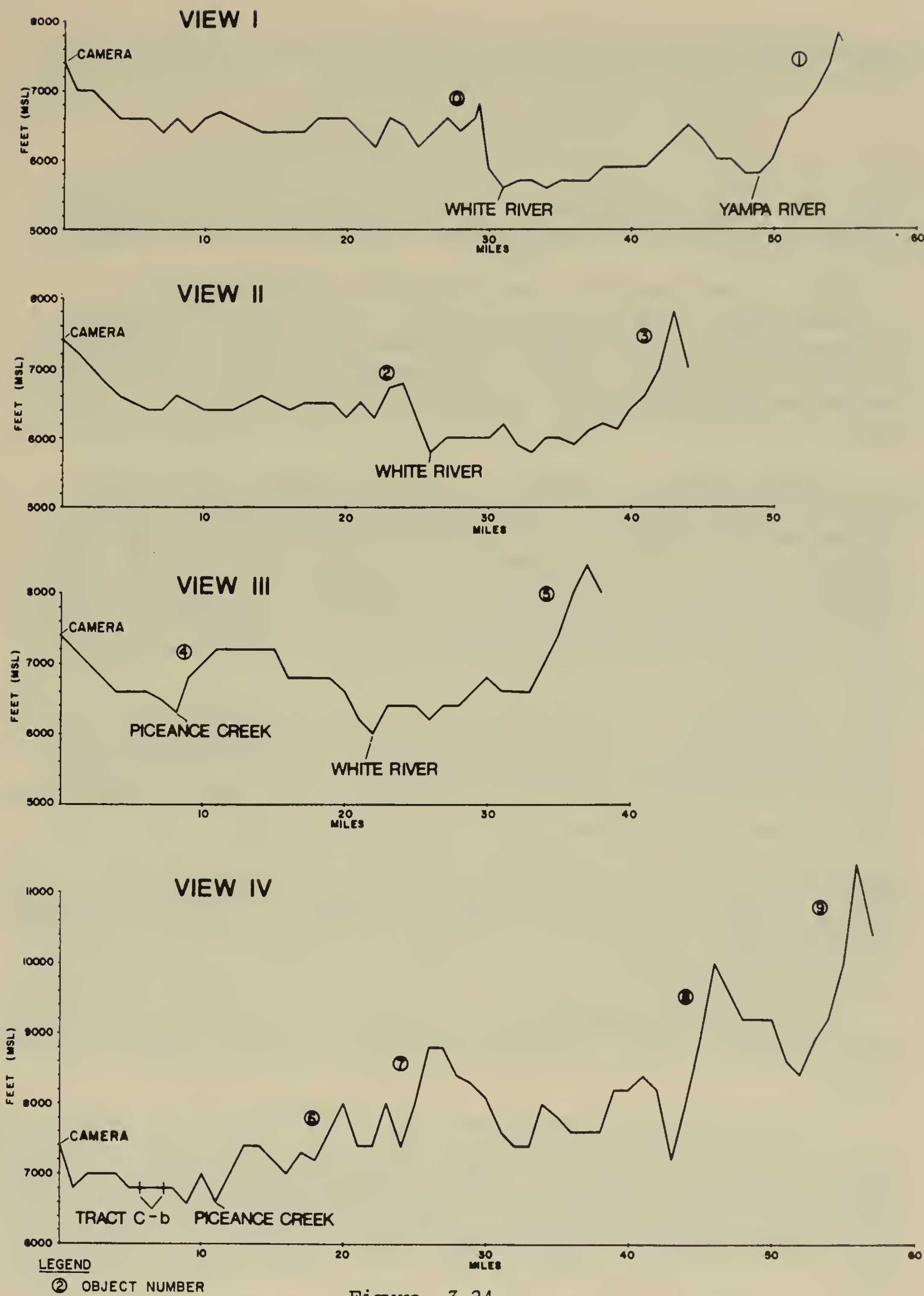


Figure 3-24

GENERALIZED CROSS SECTION OF THE TERRAIN
FOR EACH VIEW USED IN THE
PICEANCE CREEK BASIN VISIBILITY STUDY

each of four views and summed over all views. Supporting statistical information was also presented.

3.2.7.4 Brief Methodological Description

The reader is referred to the appendix, Section A.7 for a detailed discussion of both methodology and quality assurance.

The terms visibility and visibility range have been interchangeably used for several years. Their common usage is to signify the distance that something can be seen; this report distinguishes between the two. Visual range is used within a narrow sense of the concept and visibility is used in a broader context.

Visual Range - is defined in the following way: As an object is moved through the atmosphere toward the horizon sky, the contrast between the object and the sky decreases. At some distance, the contrast becomes too small to be detected by the observer, and the object vanishes. The distance from the observer to the object at the vanishing point is the VISUAL RANGE. The term visual range is used when referring to a maximum distance of sight along a single path length.

Visibility - is used as a general term, descriptive of general situations. As such it definitely has the connotation of a general state of clarity of the air. However, it does not represent an entirely subjective concept because of its connection with a given quantifiable set of values for visual range. Here visibility is used as an areal descriptor. It refers to an average of all directional visual range observations over specified periods of time. It is also used in a qualitative sense in textual description of the clarity of the air as evaluated from overviews of visual range data.

Generalized Visibility - for example, is defined as the visual range averaged over all views for time periods of seasonal and annual extent.

The photographic measurements of visual range were accomplished with a 35 mm camera attached to an 800 mm refractive lens. Black and white panchromatic film was used to photograph the objects in each view at prescribed hours every sixth day. In addition, color slides were taken concurrently with a normal focal-length lens and 35 mm camera to pictorially record the sky and weather conditions in each view.

Processing of the black and white film was accomplished in the Dames & Moore Laboratory under closely controlled conditions. Photo-

graphic chemicals were frequently replaced and processing temperatures held to within $\pm 1^0$C. Color film was not used to provide numerical data; thus it was developed through commercial sources.

Prior to development of the black and white film, the leading end of each film roll was exposed to a calibrated series of eleven different light intensities. Each film roll was exposed to these light intensities in a Kodak Process Control Sensitometer Model 101.

Once development of the film roll was complete, the densities of the eleven steps, referred to as sensitometric strip, were obtained with a MacBeth TD504 Densitometer. These densities, when plotted versus the logarithm of the exposure, provide a characteristic curve for a particular film roll. The characteristic curve provides the functional relation between exposure and image density.

Visual Range Calculations - In any photographic negative, the presence of an image is due to contrasts in light reflected by the several objects in the picture; this light enters the camera and sensitizes the film. The image on the film is created by an exposure, E, of the film proportional to the intensity of light, I, from the object. The ratio of light intensities from two objects in the same frame can be obtained from the measured densities of the two images and the characteristic curve. For example, suppose D_1 and D_2 are the image densities of two objects in the same frame. From the characteristic curve, values can be read for log E_1 and log E_2 corresponding to the image densities D_1 and D_2. The ratio of light intensities I_1 and I_2 from the two objects is:

$$I_1/I_2 = E_1/E_2$$

Steffan's method of computing visual range includes choosing the horizon sky as one of the objects. This may be denoted by replacing the subscript "2" with "∞". Object 1 at a distance x from the camera produces an image of density D_x. The horizon produces an image of density D_∞. The ratio of light intensities I_x/I_∞ is determined in the manner described above. The visual range, VR, is computed from the formula:

$$VR = Mx/\ln\ (1-I_x/I_\infty)$$

where M is related to the ability of the eye to detect contrast. It has been found that the "average" eye is capable of detecting contrasts no less than 2 percent. For such an average eye, M has the numerical value of 3.912. This equation is derived in the appendix, Section A.7.

The above equation for visual range implies that the object is black. In practice the objects are dark, but not black. However, the equation is modified to account for the non-zero reflectance of the objects. (Appendix, equation #13).

Correlation methodology of visibility with particulates and other parameters is discussed in 3.2.7.5.2 below.

3.2.7.5 Results and Discussion

This discussion consists of two parts: (1) visual range and (2) correlation of visual range with other parameters. A more detailed data presentation is contained in the appendix, Section B.2.4.

3.2.7.5.1 Visual Range

Visual ranges obtained during this baseline period were generally high; 95 percent of the measurements exceeded 41 miles; 50 percent exceeded 78 miles. Seasonally, visual ranges averaged highest during the fall of 1975, lowest during the spring of 1976 and were nearly equal during the winter of 1975-76 and summer of 1976. Daily mean visual ranges exhibited large fluctuations, especially during the fall and winter, variations of 30 to 40 miles were common.

Directional variations in the visibility were detected in every season. The largest variation in visibility occurred in a view along the Piceance Creek basin. The mean visual range in this view was the lowest each season. The generalized visibility (mean visual range) during the year-long study was 79 miles. Detailed data are presented in the appendix, Section B.2.4.

Daily Mean Visual Range - The computation of a daily mean visual range provides an indication of the prevailing visibility and conditions found in an area during the course of a day, by short-term or directional anomalies. Daily mean visual ranges in the Piceance Creek basin area were calculated for each day of monitoring based on 28 measurements from four views over a seven-hour period.

Daily mean visual ranges during the year-long study were generally high; 95 percent of the daily means were greater than 42 miles; 50 percent exceeded 76 miles. Daily means in excess of 100 miles were common, accounting for approximately one out of six days. The maximum daily mean visual range recorded was 130 miles on November 14, 1975; the minimum daily mean visual range of 32 miles was recorded on December 14, 1975 and was based on only two hours of data because of inclement weather.

Monthly Mean Visual Range - Monthly mean visual ranges were calculated from measurements obtained from all the views and hours. The monthly mean visual ranges obtained in the Piceance Creek basin area are listed in Table 3-32.

Monthly mean values occurred most frequently near 70 miles, although mean visual ranges in excess of 90 miles occurred. Of the 13 monthly mean values obtained (September, included twice), seven occurred between 67 and 74 miles; the remaining months averaged between 77 and 99 miles.

Monthly mean visual ranges during 1975 exhibited large fluctuations, exhibiting a 22 mile variation in a three month period. With the exception of February and August, visual ranges in 1976 averaged near 70 miles each month; February and August had monthly means of 84 to 94 miles, respectively.

Individual (i.e., by view) hourly maximum and minimum visual range measurements obtained in each month are also listed in Table 3-32. Maximum visual range measurements varied from 113 miles in September 1975 to 149 miles in November 1975 and February 1976. Generally, those months with high monthly mean visual ranges had the highest individual maximum values; those months with low monthly means had the lower individual maximums.

Seasonal Visual Range - Seasonally, visual ranges obtained in the Piceance Creek basin area averaged highest during the fall of 1975, lowest during the spring of 1976 and nearly equal in the winter of 1975-76 and the summer of 1976. The mean visual range (generalized visibility) and additional statistical descriptions are listed in the appendix, Section B.2.4, each season.

Visual ranges obtained during the fall were generally quite high; 50 percent of the measurements were greater than 93 miles; 95 percent exceeded 45 miles. The generalized visibility for this period was 91 miles, the highest recorded of the seasons.

Visual ranges during the winter were also high, but the distribution, shown in Figure 3-25, exhibited near uniform character over a wide range of values. During the winter the frequency of occurrence of visual ranges in excess of 100 miles dropped 10 percent from the fall and had less than a 3 percent variation from uniformity in the frequency of occurrence between 40 and 110 miles. Visual ranges during this season averaged 80 miles; 50 percent occurred above 81 miles.

Table 3-32

MONTHLY COMPOSITE VISUAL RANGE SUMMARY
PICEANCE CREEK BASIN, COLORADO
SEPTEMBER 1975-SEPTEMBER 1976
(Miles)

MONTH	MEAN[c]	HOURLY MAXIMUM	HOURLY MINIMUM	STANDARD DEVIATION
September 75[a]	77	131	42	24.0
October	89	144	44	24.6
November	99	149	24	29.0
December	86	147	17	31.1
January 76	72	137	27	29.2
February	84	149	25	28.2
March	70	116	27	19.2
April	67	138	14	27.7
May	70	124	27	16.7
June	71	117	45	14.8
July	72	120	45	15.9
August	94	147	45	20.1
September[b]	74	113	35	17.9

[a] Based on one scheduled day of photography and two half-day practice sessions.
[b] Based on four scheduled days of photography.
[c] Monthly means are based on approximately five days of photography per month.

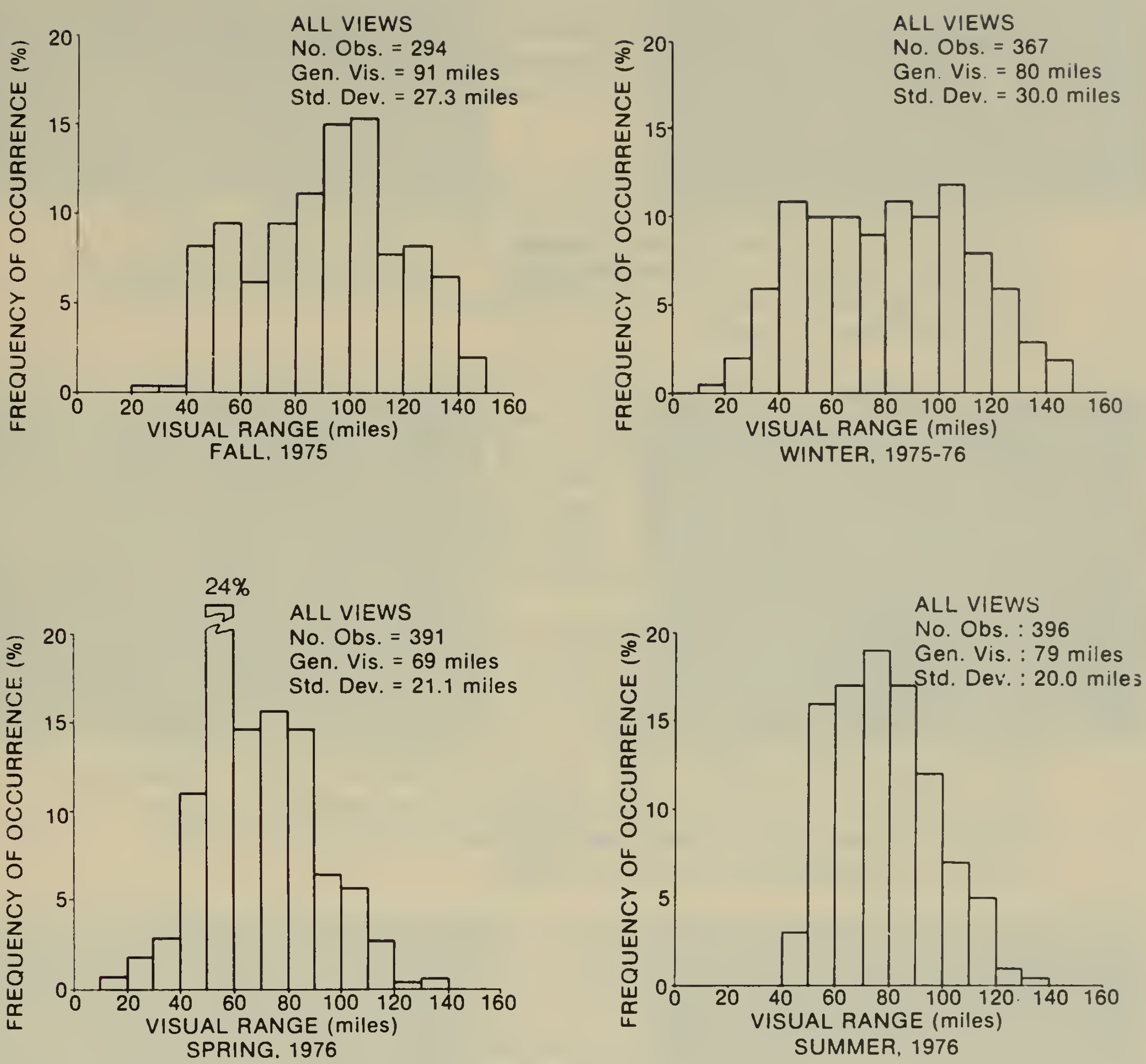


Figure 3-25

SEASONAL COMPOSITE VISUAL RANGE DISTRIBUTION
PICEANCE CREEK BASIN, COLORADO
SEPTEMBER, 1975 - SEPTEMBER, 1976

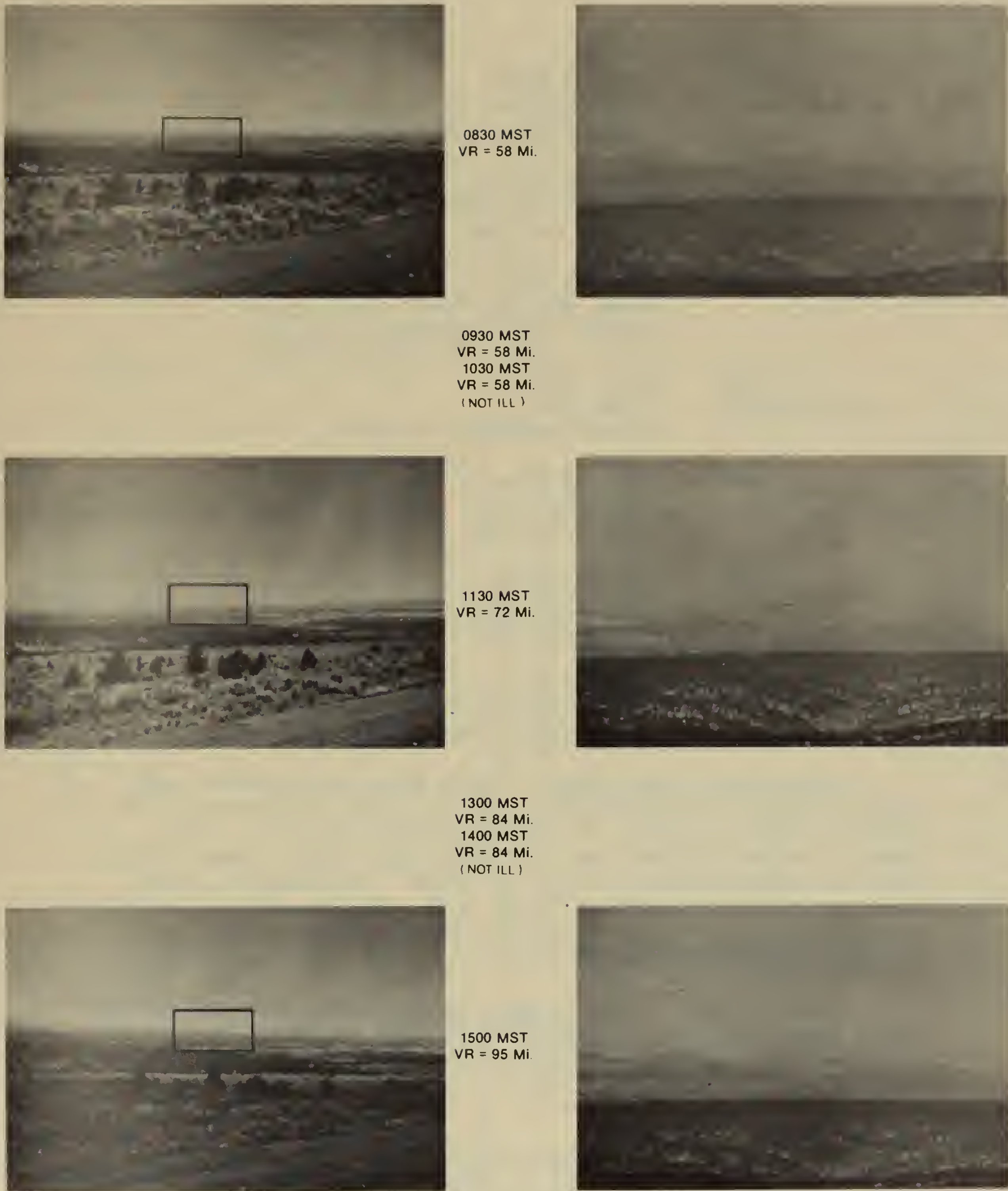
The increase in the percentage of low visual ranges exhibited during the winter was also seen during the spring. Visual range measurements in excess of 100 miles dropped to 9 percent and nearly one-fourth of all the observations made during this season fell within the 50 to 60 mile range. The generalized visibility for this season, the lowest of the four seasons, was 69 miles.

Visual ranges obtained during the summer increased from the spring values and averaged near the winter mean value. The distribution of visual range during the summer exhibited the narrowest range of the four seasons. The generalized visibility during the summer was 79 miles, 50 percent of the observations occurred above 77 miles.

The change in the generalized visibility seen during the seasons was also apparent in the mean visual range of each of the four views. The decrease in the mean visual range from the fall through spring and the recovery exhibited during the summer also occurred in all views; during no season did the mean visual range in an individual view vary from the general trend. The magnitude of changes varied, but not the direction.

Another pattern which appeared during the year was the ordering of the magnitude of the mean visual range among the views. In every season, the lowest and second lowest mean visual range occurred in Views II and III, respectively. The highest mean occurred in either View I or IV depending on the season. The recurring low mean visual range observed in Views II and III may be due to the trapping of suspended particulates in the Piceance Creek basin along View II and the influence from a center of population near View III.

To illustrate the clarity and change in contrast of the objects as the visual range changed during the day, photographs taken in View I on May 1, 1976 are shown in Figure 3-26. (Actually the large photos are taken in color; the small, high-resolution photos are black and white.) Remarks in the Site Log describe the day as "real nice," characterized by moderate haze in the morning but clearing as the wind increased as the day progressed. A synopsis of the day as described in the Site Log and the visual range obtained each hour follows:



HOURLY VARIATIONS IN VISUAL RANGE
PICEANCE CREEK BASIN, COLORADO
SEPTEMBER, 1975 - SEPTEMBER, 1976

FIGURE 3-26

0830: (illustrated)	VR = 58 miles Haze in Views I, II, and III Clear Skies, very little wind
0930:	VR = 58 miles Haze in all views, more haze to the west Clear, no wind
1030:	VR = 58 miles Haze, more in View I Clear, light breeze
1130: (illustrated)	VR = 72 miles Light Haze Clear, wind has increased
1300:	VR = 84 miles Very light haze Clear, no wind
1400:	VR = 84 miles Very light haze Clear, no wind
1500: (illustrated)	VR = 95 miles Very little haze A few widely scattered clouds, slight breeze

<u>Mean Annual Visual Range</u> - Visual range measurements made during the year-long study were generally high; 95 percent of the values exceeded 41 miles; 50 percent exceeded 78 miles. The range of values obtained was also quite high; visual range varied from less than 20 miles to near 150 miles. The distribution of these values is presented in Figure 3-27. The generalized visibility in the Piceance Creek basin area during the September 1975 to September 1976 period was 79 miles.

Hourly maximum visual ranges obtained during the year varied little among the views. Maximum values from 142 miles in View II to 149 miles in Views I and III were recorded. Hourly minimum visual ranges varied only slightly more than the maximum values, ranging from 14 miles in View III to 31 miles in View I.

A summary of visual ranges obtained during the 1975-1976 monitoring period is presented in Table 3-33 for each view and for the composite of the views. Variation in the mean visual range of the four views presented in Table 3-33 illustrated in Figure 3-28 reflects the seasonal trends.

The distribution found for View I is unusual. The largest percentage of visual range obtained in View I occurred between

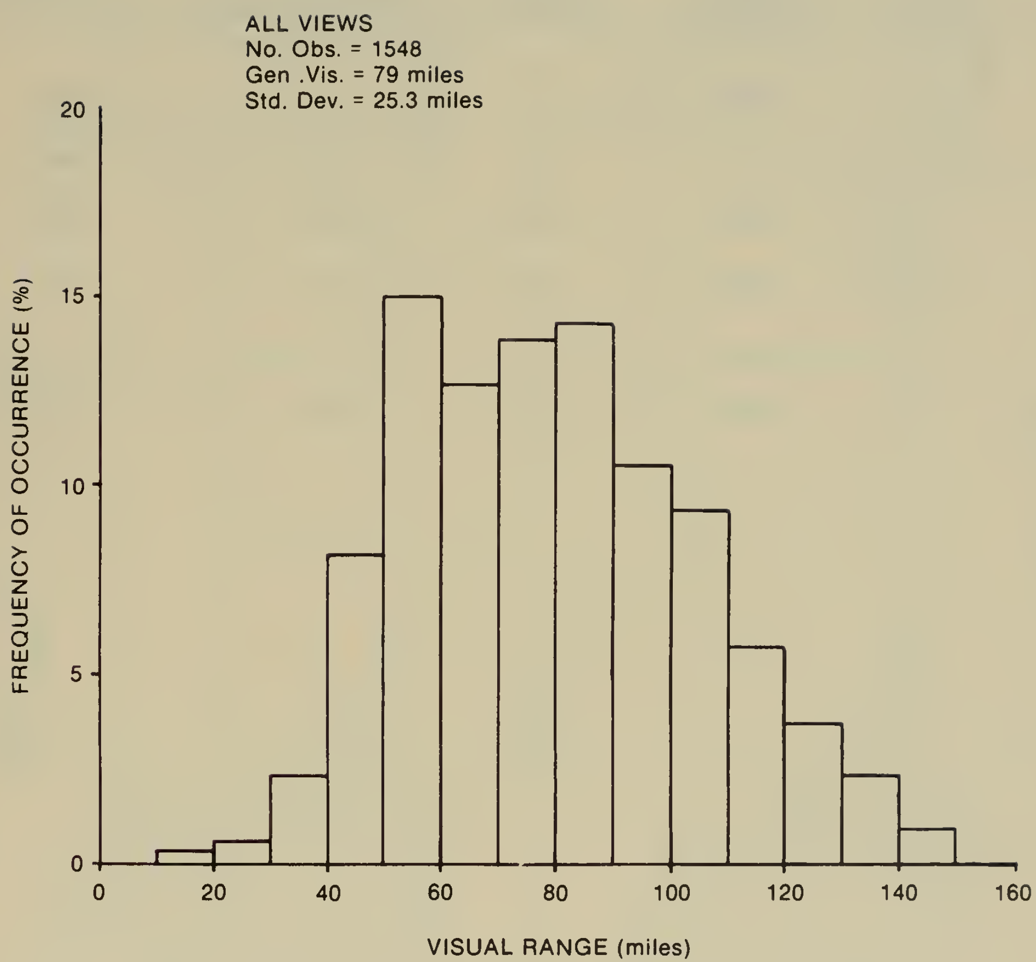


Figure 3-27

ANNUAL COMPOSITE VISUAL RANGE DISTRIBUTION
PICEANCE CREEK BASIN, COLORADO
SEPTEMBER, 1975 - SEPTEMBER, 1976

Table 3-33

ANNUAL VISUAL RANGE SUMMARY (MILES)
PICEANCE CREEK BASIN, COLORADO
SEPTEMBER 1975-SEPTEMBER 1976

VIEW	MEAN	HOURLY MAXIMUM	HOURLY MINIMUM	5 PERCENTILE	STANDARD DEVIATION
I	83	149	31	50	23.0
II	69	142	31	42	19.2
III	78	149	14	35	26.6
IV	85	148	22	41	28.8
Composite	79	149	14	41	25.3

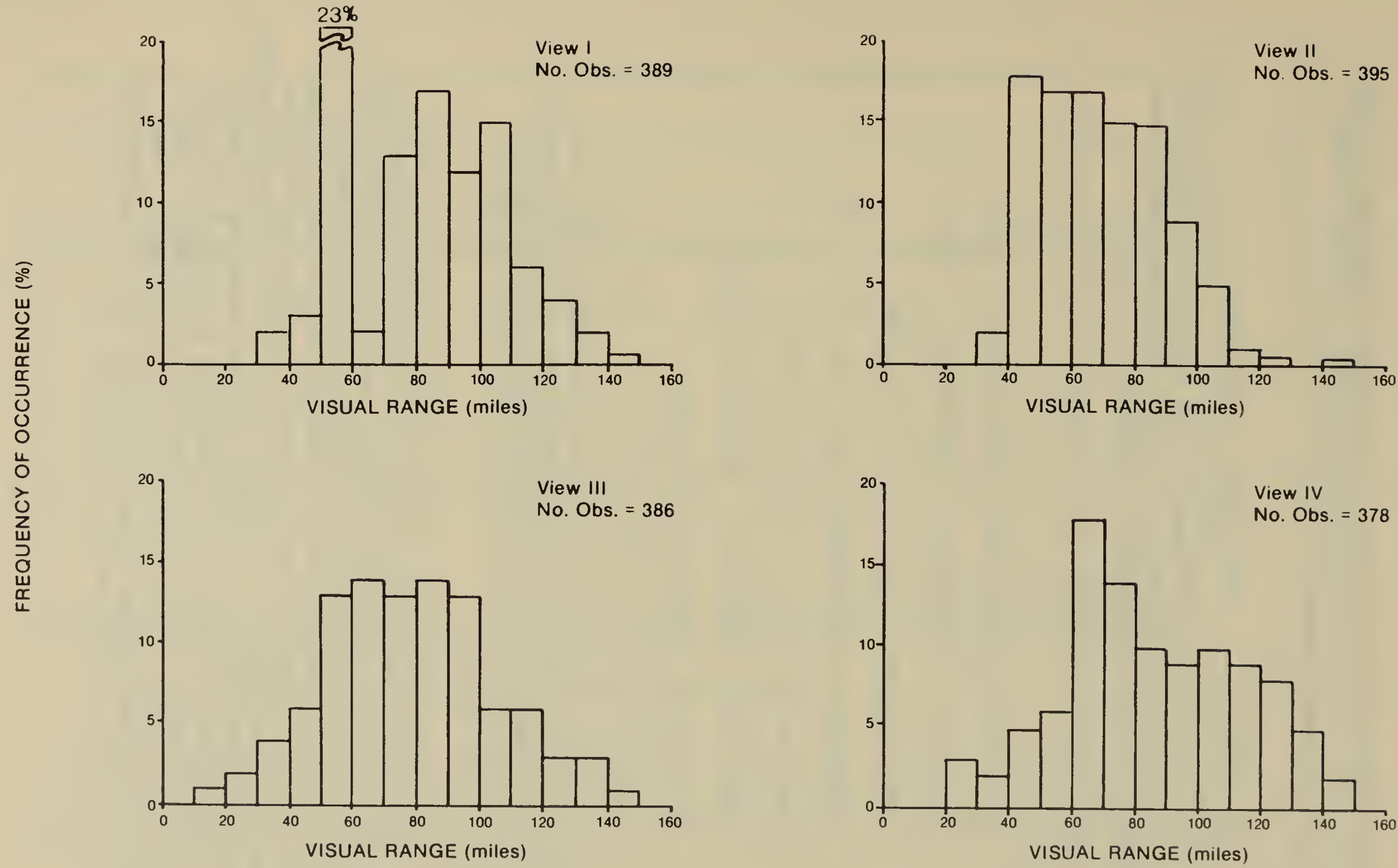


Figure 3-28

DISTRIBUTION OF VISUAL RANGE IN EACH VIEW
PICEANCE CREEK BASIN, COLORADO
SEPTEMBER, 1975 - SEPTEMBER, 1976

50 and 60 miles, yet a very small percentage occurred in the next interval, 60-70 miles. Distributions in View I similar to this were found in every season.

3.2.7.5.2 Visual Range Correlations

The objective of this study was to determine if significant correlations existed between daily visual range and observations of several air quality parameters taken at the same time.

Observations of daily values for the following parameters were utilized:

- particulate mean 24-hour concentrations - $\mu g/m^3$

- mean hourly wind speed at Station 023, 30 foot - mph

- total daytime solar radiation - langleys

- mean hourly ozone concentration - $\mu g/m^3$

- mean hourly relative humidity - percent

- mean hourly temperature - degrees Fahrenheit

- total daily precipitation - inches

- maximum hourly wind speed - mph

These observations for every sixth day were tabulated by date with the composite visual range averaged over all four views and are shown in Table 3-34. Mean hourly wind speed and maximum hourly wind speed values were squared, and cubed and also entered in the table.

Regarding methodology the data shown in Table 3-34 were used as inputs to two computer programs. The first program was a multiple linear regression model that was used to compute paired correlation coefficients of each parameter with visual range. Other statistics included mean, standard deviation, and multiple regression coefficients. This program was used in an iterative manner where parameters were deleted one at a time in the iterations to focus on the predictive capability of the remaining parameters for visual range. The second program was a polynomial-fit model with plotted output. First and second degree polynomials were computed and plotted to provide visibility to the data. Some discussion of the multiple linear regression model is appropriate and is included in the appendix, Section B.2.4.

Table 3-34
COMPARISON OF DAILY VISUAL RANGE
WITH OTHER PARAMETERS

DAILY VALUES AT STATION 023

VISUAL RANGE (mi)	PART. (µg/ m3/	SPEED 30' (mph)	SOLAR RAD. (LANG)	OZONE (µg/m3)	REL. HUM. %	TEMP. (°F)	TOTAL PRECP. (in)	MAX WIND SPEED (mph)	DATE MM.DD.YY	MEAN WIND SPEED SQUARED mph2	MEAN WIND SPEED CUBED mph3	MAX WIND SPEED SQUARED mph2	MAX WIND SPEED CUBED mph3
103.	18.	5.	469.	53.	19.	57.	0.00	15.	9.25.75.	25.	125.	225.	3375.
87.	20.	7.	384.	54.	22.	59.	0.00	23.	9.26.75.	49.	343.	529.	12167.
59.	27.	5.	459.	51.	32.	50.	0.00	14.	9.27.75.	25.	125.	196.	2744.
93.	10.	4.	427.	50.	21.	58.	0.00	13.	10. 3.75.	16.	64.	169.	2197.
116.	13.	7.	382.	43.	28.	46.	0.00	16.	10. 9.75.	49.	343.	256.	4096.
66.	8.	4.	396.	37.	49.	41.	0.00	14.	10.15.75.	16.	64.	196.	2744.
99.	17.	8.	342.	50.	22.	53.	0.00	15.	10.21.75.	64.	512.	225.	3375.
63.	27.	14.	224.	36.	60.	40.	0.00	29.	10.27.75.	196.	2744.	841.	24389.
106.	1.	3.	261.	35.	52.	41.	0.00	11.	11. 2.75.	9.	27.	121.	1331.
66.	1.	4.	14.	27.	95.	33.	0.04	12.	11. 8.75.	16.	64.	144.	1728.
130.	5.	5.	204.	36.	28.	41.	0.00	13.	11.14.75	25.	125.	169.	2197.
80.	2.	3.	205.	39.	69.	16.	0.00	8.	11.20.75.	9.	27.	64.	512.
95.	5.	10.	20.	43.	66.	13.	0.00	21.	11.26.75.	100.	1000.	441.	9261.
98.	2.	5.	183.	40.	60.	36.	0.00	13.	12. 2.75.	25.	125.	169.	2197.
88.	4.	3.	112.	34.	58.	36.	0.00	7.	12. 8.75.	9.	27.	49.	343.
32.	4.	8.	83.	42.	85.	11.	0.00	17.	12.14.75.	64.	512.	289.	4913.
109.	1.	2.	183.	38.	56.	24.	0.00	7.	12.20.75.	4.	8.	49.	343.
53.	2.	10.	71.	45.	56.	25.	0.00	26.	12.27.75	100.	1000.	676.	17576.
44.	2.	2.	224.	41.	77.	3.	0.00	8.	1. 2.76.	4.	8.	64.	512.
66.	2.	9.	73.	35.	57.	27.	0.00	20.	1. 8.76.	81.	729.	400.	8000.
102.	1.	5.	218.	45.	44.	24.	0.00	16.	1.14.76.	25.	125.	256.	4096.
91.	6.	2.	290.	35.	61.	23.	0.00	6.	1.20.76	4.	8.	36.	216.
57.	5.	5.	102.	35.	68.	14.	0.00	15.	1.26.76.	25.	125.	225.	3375.
105.	1.	4.	302.	41.	41.	34.	0.00	9.	2. 1.76.	16.	64.	81.	729.
46.	6.	4.	265.	31.	77.	28.	0.00	15.	2. 7.76.	16.	64.	225.	3375.
85.	1.	4.	348.	41.	62.	36.	0.00	11.	2.13.76.	16.	64.	121.	1331.
102.	1.	16.	353.	43.	55.	32.	0.09	33.	2.19.76.	256.	4096.	1089.	35937.
79.	7.	7.	377.	45.	41.	33.	0.00	20.	2.25.76.	49.	343.	400.	8000.
37.	45.	9.	174.	45.	83.	22.	0.51	23.	3. 2.76.	81.	729.	529.	12167.
61.	8.	2.	402.	53.	60.	27.	0.00	6.	3. 8.76.	4.	8.	36.	216.
65.	3.	13.	316.	45.	58.	33.	0.00	26.	3.14.76.	169.	2197.	676.	17576.
85.	22.	10.	505.	39.	46.	23.	0.00	22.	3.20.76.	100.	1000.	484.	10648.
75.	2.	5.	564.	43.	62.	25.	0.00	12.	3.26.76.	25.	125.	144.	1728.
101.	24.	15.	554.	47	29.	47.	0.00	31.	4. 1.76.	225.	3375.	961.	29791.
45.	4.	4.	188.	37.	78	36.	0.00	10.	4. 7.76.	16.	64.	100.	1000.
78.	60.	14.	331.	66.	67.	40.	0.00	33.	4.13.76.	196.	2744.	1089.	35937.
56.	3.	4.	326.	64.	80.	36.	0.00	14.	4.19.76.	16.	64.	196.	2744.
72.	6.	10.	222.	86.	30.	48.	0.00	25.	4.25.76.	100.	1000.	625.	15625.
75.	16.	4.	672.	78.	38.	46.	0.00	14.	5. 1.76.	16.	64.	196.	2744.
56.	3.	4.	278.	72.	71.	46.	0.00	14.	5. 7.76.	16.	64.	196.	2744.
76.	8.	6.	699.	82.	38.	54.	0.00	18.	5.13.76.	36.	216.	324.	5832.
58.	16.	7.	335.	76.	47.	56.	0.13	24.	5.19.76.	49.	343.	576.	13824.
65.	6.	10.	195.	90.	46.	56.	0.00	26.	5.25.76.	100.	1000.	676.	17576.
88.	13.	7.	604.	82.	47.	56.	0.00	14.	5.31.76.	49.	343.	196.	2744.
59.	24.	10.	526.	78.	38.	63.	0.05	24.	6. 6.76.	100.	1000.	576.	13824.
84.	9.	9.	507.	70.	50.	50.	0.00	21.	6.12.76.	81.	729.	441.	9261.
68.	4.	8.	686.	64.	64.	50.	0.00	20.	6.18.76.	64.	512.	400.	8000.
81.	15.	6.	705.	94.	43.	52.	0.00	17.	6.24.76.	36.	216.	289.	4913.
62.	33.	10.	615.	78.	42.	67.	0.00	28.	6.30.76.	100.	1000.	784.	21952.
71.	33.	8.	579.	70.	35.	74.	0.00	19.	7. 6.76.	64.	512.	361.	6859.
61.	53.	8.	566.	90.	45.	71.	0.00	23.	7.12.76.	64.	512.	529.	12167.
62.	14.	7.	456.	59.	79.	63.	0.31	20.	7.18.76.	49.	343.	400.	8000.
92.	14.	6.	509.	92.	45.	69.	0.00	13.	7.24.76.	36.	216.	169.	2197.
68.	17.	6.	568.	72.	53.	69.	0.07	25.	7.30.76.	36.	216.	625.	15625.
96.	7.	5.	665.	72.	43.	62.	0.00	17.	8. 5.76.	25.	125.	289.	4913.
18.	8.	10.	438.	59.	60.	59.	0.10	24.	8.11.76.	100.	1000.	576.	13824.
94.	23.	13.	346.	49.	47.	67.	0.00	25.	8.17.76.	169.	2197.	625.	15625.
69.	12.	9.	501.	53.	55.	66.	0.00	19.	8.23.76.	81.	729.	361.	6859.
109.	8.	6.	532.	59.	39.	67.	0.00	17.	8.29.76.	36.	216.	289.	4913.
84.	11.	4.	542.	59.	34.	68.	0.00	14.	9. 4.76.	16.	64.	196.	2744.
86.	3.	7.	261.	53.	67.	57.	0.00	14.	9.10.76.	49.	343.	196.	2744.
64.	8.	9.	411.	57.	54.	62.	0.00	19.	9.16.76.	81.	729.	361.	6859.
54.	3.	6.	170.	49.	83.	49.	0.00	20.	9.22.76.	36.	216.	400.	8000.

A summary of the visual range correlations is shown in Table 3-35. These summary data were derived from the multiple linear regression program. Visual range was the dependent variable in each of these runs (iterations), with the 12 independent variables identified in the parameter column. The first eight parameters are the primary independent variables with the last four representing squared and cubed values of mean hourly wind speed and maximum hourly wind speed respectively.

The coefficient of correlation is the measure of the independence of two variables. If the two variables are independent, the coefficient of correlation (r) is zero or is near zero, since r is an estimate to the true population measure of independence. The hypothesis of independence between the two variables can be tested at various confidence levels under the assumption that both are normally distributed. The 95 percent confidence interval for r in a sample size of 63 is:

$$-0.249 < r < +0.249.$$

Two variables are thus independent if r is within this confidence interval. Results indicated there was significant correlation between visual range and relative humidity ($r = -0.560$) since these values of $|r|$ were greater than 0.249. The negative sign means an increase in either relative humidity or precipitation results in a reduction in visual range.

The remaining part of Table 3-35 presents the results of multiple linear regressions obtained by first utilizing only the eight primary independent variables. Visual range was the dependent variable. The multiple correlation coefficient for this run was 0.694. This case is presented in the appendix, Section B.2.4, where the F-ratio is calculated at 6.28. This is a statistically significant correlation since any value of F greater than 2.58 is outside the 95 percent confidence interval.

The results of subsequent multiple linear regression iterations with one independent variable deleted at a time on the basis of lowest T value are presented in Table 3-35 also. Only variables with regression coefficients listed were in that specific iteration. In general notation, the correlation coefficients (b_i) and intercepts (b_o) are the coefficients for the regression equation for predicting visual range (Y_{est}), given the observations (X_i) of the n independent variables.

$$Y_{est} = b_o + \sum_{i=1}^{n} (b_i X_i).$$

In all cases the F-ratio (not shown) is significant. The intercept is the predicted visual range if all independent-variable observations are zero. The standard error of the estimate is the standard deviation in miles of the estimated visual range.

Table 3-35 SUMMARY OF VISUAL RANGE CORRELATION AND REGRESSION ANALYSES

Parameter	Units	Mean	Std Dev.	Coef. Corr.	Multiple Regression Coefficients Primary Variables								Multiple Regression Coef. Primary and Secondary Var.					
1. Particulates	$\mu g/m^3$	11.7	12.5	-.125	-.196	-.209	-.213	-.204	---	---	---	---	-.184	-.189	-.197	-.220	---	---
2. Wind Speed-30'	mph	6.92	3.35	-.072	2.79	2.84	2.84	2.81	2.83	---	---	---	15.1	14.9	---	---	---	---
3. Solar Radiation	langleys	364.	182.	.118	-.002	-.002	---	---	---	---	---	---	-.014	-.014	-.004	---	---	---
4. Ozone	$\mu g/m^3$	54.4	17.6	-.111	-.261	-.258	-.266	-.236	-.264	-.340	-.409	---	-.141	-.141	-.233	-.247	---	---
5. Rel. Humidity	%	52.7	17.6	-.560	-.809	-.819	-.815	-.834	-.819	-.837	-.829	-.694	-.819	-.822	-.810	-.812	-.738	-.722
6. Temperature	^oF	44.0	17.4	.114	.070	.068	.062	---	---	---	---	---	.155	.155	.063	.047	---	---
7. Precipitation	in.	.021	.078	-.304	-6.42	---	---	---	---	---	---	---	-1.73	---	-6.85	---	---	---
8. Max. Wind Speed	mph	17.7	6.64	-.179	-1.80	-1.83	-1.82	-1.80	-1.97	-.607	---	---	-6.72	-6.61	---	---	---	---
9. (Wind Speed)^2	(mph)^2	58.6	56.7	-.022	---	---	---	---	---	---	---	---	-1.88	-1.84	-.184	.185	.260	---
10. (Wind Speed)^3	(mph)^3	586.	847.	.031	---	---	---	---	---	---	---	---	.080	.079	---	---	---	---
11. (Max. Wind Speed)^2	(mph)^2	356.	257.	-.145	---	---	---	---	---	---	---	---	.080	.079	-.046	-.046	-.070	-.018
12. (Max. Wind Speed)^3	(mph)^3	7960.	8304.	-.103	---	---	---	---	---	---	---	---	-.003	-.002	---	---	---	---
13. Visual Range	mi.	76.1	21.8	---	DEP	DEP	DEP	DEP	DEP	DEP	DEP	DEP	DEP	DEP	DEP	DEP	DEP	DEP
Intercept (m)					146.	146.	146.	148.	149.	149.	142.	113.	152.	152.	138.	138.	125.	120.
Multiple Correlation Coefficient					.694	.694	.694	.692	.686	.665	.642	.560	.740	.740	.692	.692	.662	.598
Standard Error of Estimate (mi).					16.8	16.7	16.5	16.4	16.4	16.7	17.0	18.2	16.4	16.2	16.9	16.6	16.8	17.8

Computer plots of visual range as functions of the primary and secondary variables are shown in the appendix, Section B.2.4. These figures show the scatter diagrams of the paired observations. The linear regression line of visual range on the independent variable is also plotted. These plots provide visibility to the scatter of the data and relationship of visual range to the variable. In all cases, the variability is quite large. The correlation between visual range and relative humidity is the most significant of all the parameters and is shown in Figure 3-29 as a negative correlation. Asterisks on this figure represent the regression line; a number means that number of data points which are superimposed.

Table 3-36 presents a summary of the correlation results of Table 3-35 whereupon the independent variables are ranked (highest to lowest correlation) on the basis of both the correlation coefficient and the highest T value. The highest T value is regarded as a relative measure of the contribution of a particular variable to the regression equation and a somewhat better correlation indicator than the correlation coefficient. Also shown for comparison are the previously mentioned particulates results derived from Table 3-17.

Precipitation had a higher correlation coefficient than ozone. Precipitation had fewer non-zero values; ozone proved to be a better predictor of visual range than precipitation. As was previously mentioned, relative humidity ranked best by both criteria. Wind correlated well because it stirred up the particulates which are primarily fugitive dust.

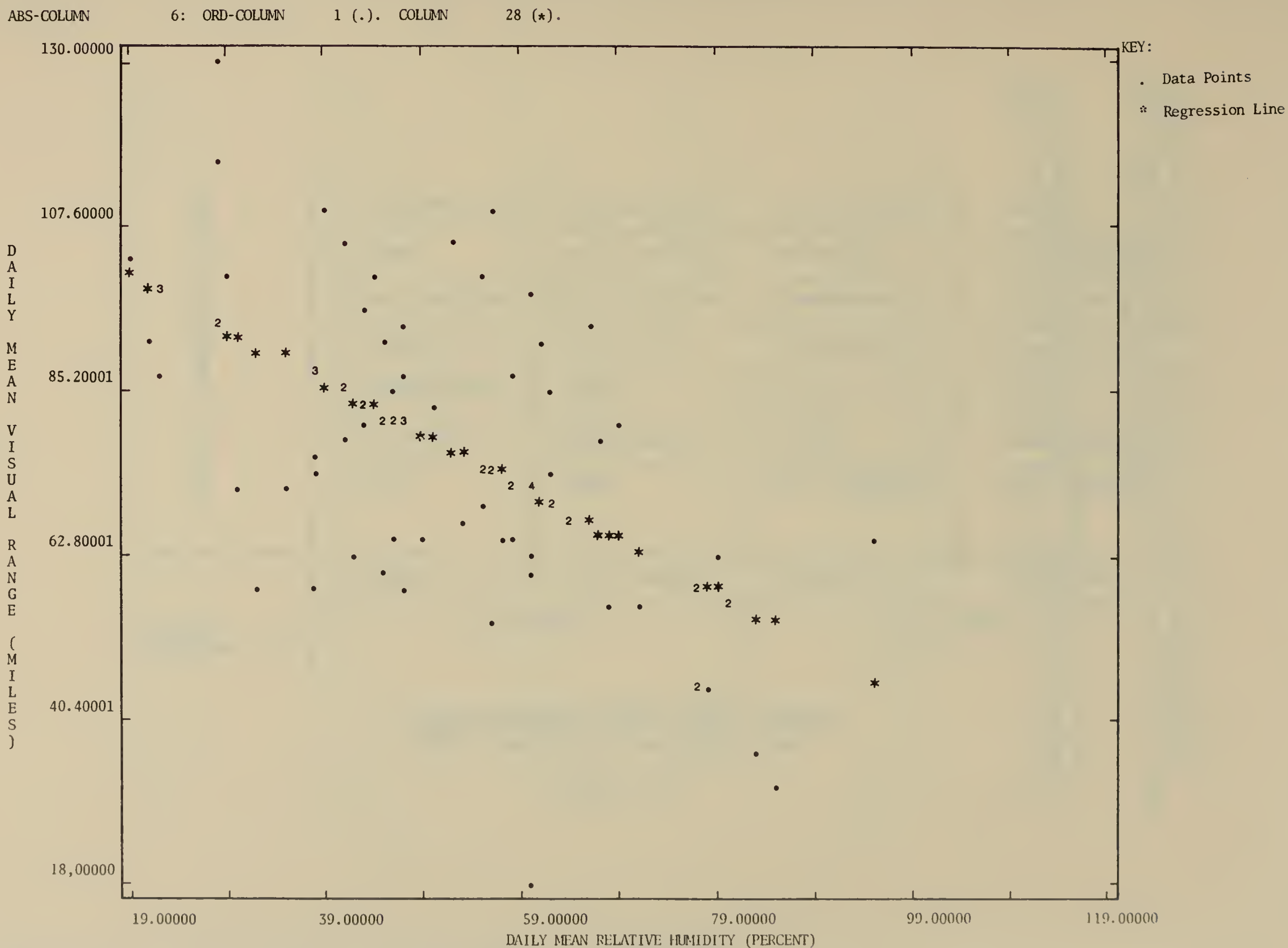
3.2.7.5.3 Conclusions

1) Area-wide visual range measurements conducted every sixth day over approximately a one-year period utilizing photographic photometry were regarded as successful in that 89 percent of the planned 1732 measurements were obtained even though the Hunter Creek site is remote. Visual range was reported as daily, monthly, seasonal, and annual averages by each of four views and for the composite.

2) Visual ranges were generally high; 95 percent exceeded 41 miles; 50 percent exceeded 78 miles. Seasonally, visual ranges averaged highest in the fall of 1975 (91 miles), lowest during the spring of 1976 (69 miles), and were nearly equal in the winter of 1975-1976 and summer of 1976 (80 miles). Mean annual visual range was 79 miles.

3) Mean visibility was lowest in the view along Piceance Creek basin in all seasons, possibly due to trapping of suspended particulates. But this has not been proven.

OMNITAB LINEAR AND 2ND DEG REGRESS WITH PLOTS--VISUAL RANGE VS ATMOSPHERE



TOTAL NO. OF PTS. PLOTTED IS 118 AND NO. NOT PLOTTED BECAUSE THEY FALL OUTSIDE OF BOUNDS IS 0

Figure 3-29 COMPUTER PLOT OF VISUAL RANGE VARIATION WITH RELATIVE HUMIDITY

Table 3-36

RANKED CORRELATION COMPARISONS FOR
PARTICULATES AND VISUAL RANGE STUDIES

Dependent Variable →	Particulates		Visual Range	
	Highest T	Corr. Coeff.	Highest T	Corr. Coeff.
Ranked Independent Variables	Wind	Wind	Rel. Humidity	Rel. Humidity
	Solar Rad.	Temperature	Ozone	Precipitation
	Precipitation	Ozone	Wind	Wind
	Temperature	Solar Rad.	Particulates	Particulates
	Rel. Humidity	Precipitation	Temperature	Solar Rad.
	Ozone	Rel. Humidity	Solar Rad.	Temperature
	Soil Moisture	Soil Moisture	Precipitation	Ozone

4) Visual range correlates best with relative humidity (negatively) with ozone and wind as the next best predictors. Recalling the particulates correlation, it correlated best with wind, solar radiation, and precipitation.

5) Visibility is a parameter easily understood by the layman and its measurements should be continued by these baseline techniques at the same site on a periodic but intermittent basis.

3.3 Noise

3.3.1 Piceance Basin Traffic Noise

3.3.1.1 Rationale

The State of Colorado obtained traffic levels in 1974 at 13 stations in the general area of the Piceance Basin and in the towns of Rangely, Meeker, and Rifle. This approach attempts to derive traffic noise levels from traffic densities at specific density-measurement sites in the Piceance Basin.

3.3.1.2 Objectives

The objective of this study was to obtain traffic noise levels during an average 24-hour day in 1974 along key roads in the Piceance Basin.

3.3.1.3 Experimental Design

The State Highway Department sampled traffic levels at the 13 sampling stations shown on Figure 2-5 in 1974. Traffic noise levels were sought as a function of traffic load.

3.3.1.4 Methodology

The State Highway Dept. provided a correlation curve to estimate noise from traffic level at locations 500 feet from the highway. Results are presented on Table 2-21 in terms of the sound level that is exceeded 10 percent of the time over a one-hour duration.

3.3.1.5 Results and Discussion

State Highway 6 (now I-70) both east and west of Rifle proved to be the noisiest with a sound level of 66 dbA exceeded 10 percent of the time. The three sampling stations on Piceance Creek Road were the quietest sampling locations with 53 dbA exceeded 10 percent of the time.

3.3.2 Environmental Baseline Noise Program

3.3.2.1 Rationale

This program was not required under the lease but was requested by the Area Oil Shale Supervisor. General background noise levels were sought on the Tract and surrounding vicinity prior to Tract development.

3.3.2.2 Objectives

To provide representative background noise level measurements in the vicinity of the C-b Tract including locations along access roads and along Tract boundaries.

3.3.2.3 Experimental Design

Measurements were made one day per month at the 14 locations described in Section 2.5.2 and shown on Figure 2-4 over a 14 month span starting in September 1975.

3.3.2.4 Methodology

Methodology and quality assurance are described in the appendix, Section A.8. A General Radio 1565 sound level meter has been used to obtain measurements at A, B, and C-weightings. These weightings are explained in the appendix.

3.3.2.5 Results and Discussion

Measured noise levels (A weighting) above background at each station are presented in Table 3-37. A blank indicates background level as indicated along the bottom row of the chart. Locations I and II were along Piceance Creek Road and measurements were always made in the presence of passing vehicles. It is of interest to note that the traffic noise analysis of Section 3.3.1 indicated an average level at a station on Piceance Creek Road near Hunter Creek to be 53 dbA exceeded 10 percent of the time. Peak noise level was 83 from a road scraper in July 1976.

On-Tract activity diminished from December 1975 to almost zero in 1976 in terms of noise level as indicated on the table. Noisiest activity at any Tract boundary (East, Sta. XI) was that due to the jet test in November and December 1975 producing up to 75 dbA. For the most part the Tract has been very quiet.

Table 3-37 ENVIRONMENTAL NOISE

Measured dbA above Background*

Station	Month													
	S '75	O	N	D	J '76	F	M	A	M	J	J	A	S	O
I	29 Truck	30 Pickup	14 Truck	17 Truck	29 Truck	23 Car	32 Pickup	17 Pickup	33 Car	34 Pickup	26 Truck	23 Car	26 Truck	23 Jeep
II	40 Truck	29 Car	25 Truck	25 Truck	38 Road Scraper	28 Truck	33 Pickup	19 Truck	31 Pickup	29 Pickup	34 Truck	27 Pickup	31 Pickup	28 Pickup
III			6 Wind	6										
IV				37 Swab. Rig										
V														
VI														
VII				5										
VIII			7	7										
IX														
X			5 Wind											
XI			27 Jet Test	29										
XII	5 Idling Tractor													
XIII														
XIV	5 Wind		6 Wind											
Background	46	45	46	46	45	45	45	49	45	45	45	44	45	45

*No entry = Background Level

3.3.3 Conclusions

1) Regarding Piceance Basin traffic noise, of the 13 sampling locations throughout the Basin, Highway I-70 both east and west of the town of Rifle proved to be the noisiest location with a sound level of 66 dbA exceeded 10 percent of the time. Results were obtained from a correlation of noise intensity with traffic load.

2) Traffic load was estimated by the State of Colorado in 1974; periodic updates every two or three years are suggested.

3) Environmental baseline noise levels in the vicinity of the Tract have been low. As construction activity at the Tract increases, the discrete noise measurement technique should be changed to continuous measurements on a periodic basis.

4 PROGRAM UTILIZATION

In essence this chapter deals primarily with an answer to the question: How can the baseline "experience" be utilized to guide the environmental monitoring program? Other related uses for the data are considered in the section to follow.

4.1 Data Uses

General categories of utilization of the baseline data are (a) to assess the current status of air quality and noise, (b) to make continual comparisons with air quality standards to assess compliance, (c) to determine the nature of long-term trends from the baseline, (d) to determine pollution control system effectiveness by ambient monitoring in a general downwind direction, (e) to identify problems requiring corrective action hopefully before damage occurs, (f) to provide structural design criteria on the basis of baseline and other information, (g) to provide an historical climatological data base, (h) to provide inputs to air diffusion models, and (i) to provide input to the overall environmental program. Most of these uses relate to the next environmental phase called Environmental Monitoring. Structural design criteria and diffusion modeling inputs are singled out separately, first.

4.2 Structural Design Criteria

Proposed structural design criteria based on a combination of baseline data and other sources are presented on Table 4-1. Inasmuch as selection of the applicable design criteria are the domain of the design engineers these should be viewed solely as recommendations. Commentary is in order on several of these.

4.2.1 Temperature

The annual temperature range of 150°F represents one of the widest in the U.S. On two consecutive years minimum temperatures in Piceance Valley have reached -51°F.

4.2.2 Winds

Maximum winds have been estimated from the data of limited time history in the Piceance Basin, including, but not limited to, baseline data. This extreme wind analysis by Marlatt 1975 has utilized a Fréchet distribution in estimation of design wind speeds as functions of risk and return period for the C-b Tract as shown on Figure 4-1. Given a wind speed of design value, x, the figure yields the probability (P) or risk of an annual extreme wind exceeding this design value. Actually F(x) is plotted, where F(x) = 1-P. Gusts of 30-second duration are utilized here.

The return period (R) or time expected between successive extreme winds of the design level is given by R = 1/P. Note that the probability of at least one extreme wind exceeding the design value in m years is

$$P_m = 1-(F(x))^m.$$

For example if a return period of 100 years is selected as desirable (and as proposed for the C-b situation) then P = 1/R = 0.01 or the annual risk is 1 percent. Thus F(x) = 1-P = 0.990 which, from Figure 4-1 yields a design wind of 100 mph. Setting m equal to the 65-year design life of the project yields

$$P_m = 0.48.$$

Table 4-1
ENVIRONMENTAL DESIGN CRITERIA

ITEM	UNITS	VALUE On-Tract	VALUE Off-Tract
Max. Air Temperature	°F	101	101
Max. Design Temperature	°F	100	100
Min. Air Temperature	°F	-26	-51
Min. Design Temperature	°F	-35	-50
Design Wet Bulb Temperature	°F	80	80
Rainfall-Yearly			
Average	In.	13	13
Design	In.	20	20
10 year Intensity (1 hr.)	In./hr.	0.9	0.9
100 year Intensity (1 hr.)	In./hr.	1.3	1.3
Wind Speed			
Arith. Avg.	mph	8	6
Max. Design	mph	100	100
Wind Dir.-Predom.			
Spring	Sector	SSW	Pic. Cr.: ESE
Summer	Sector	SSW	E
Fall	Sector	S	E
Winter	Sector	SSW	ESE
Snowfall			
Avg. Annual	In.	70	70
Design Snowpack	In.	36	36
Frost Line Depth	In.	16	24
Lightning Storms	Number	12	12
Dust Storms-Provisions	Yes/No	Yes	Yes
Stream Flow			
10 year flood	cfs	50	350 Pic. Cr.

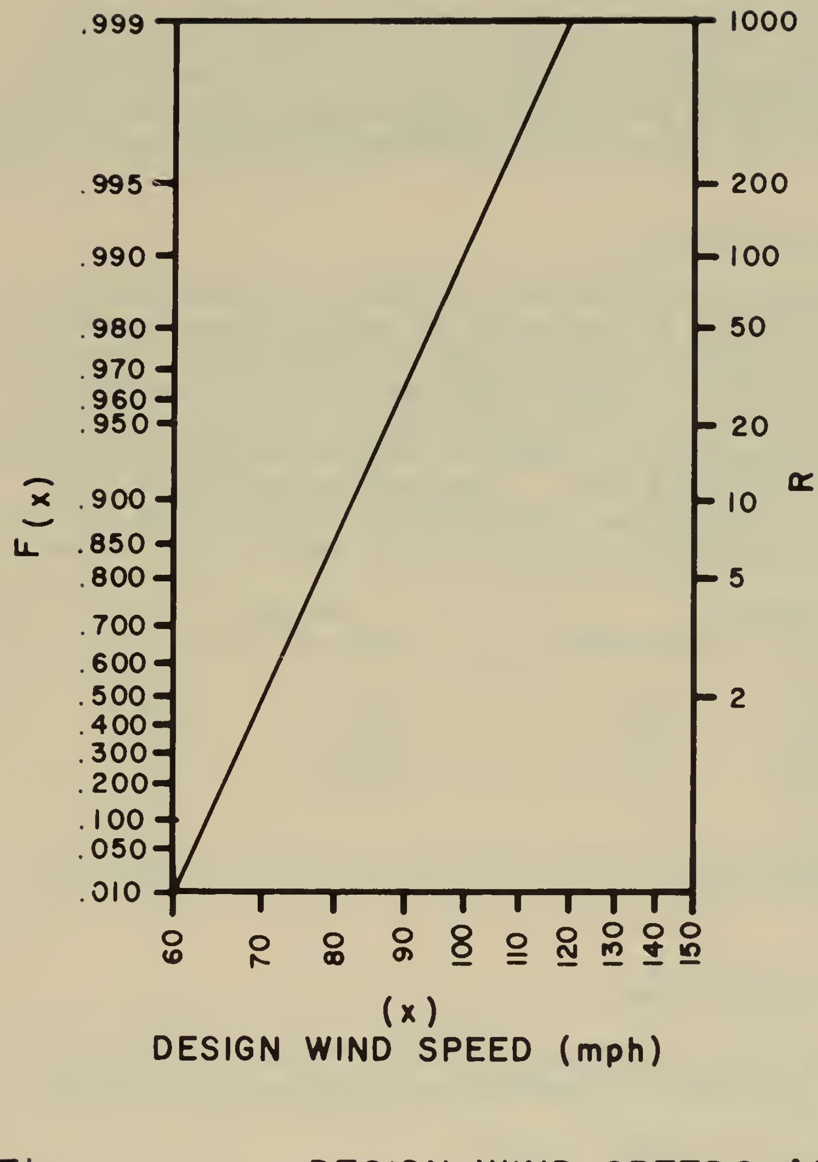


Figure 4-1 DESIGN WIND SPEEDS AS FUNCTIONS OF RISK AND RETURN PERIOD FOR THE C-b TRACT. (FRÉCHET DISTRIBUTION)

Thus the risk of at least one 30-second extreme wind exceeding 100 mph in 65 years is 48 percent for an annual risk of a 100 mph wind of only 1 percent. This analysis will be updated as the period of record increases.

Regarding wind direction, local terrain has a major influence on wind direction in the area. In Piceance Creek winds are constrained by the valley walls to flow up-creek (to the ESE) in the daytime and down creek (WNW) at night. Winds on the Tract at the meteorological tower are more synoptic-like with the predominant direction being SSW. At Station 024 near the northern border, flows are mixed (between plateau and creek) but are more creek-like in the predominant direction.

4.2.3 Precipitation

Precipitation data from the air quality stations have not been highly reliable so that heavy reliance has been placed in the estimates utilizing the neighboring Little Hills, Altenbern, Meeker, Grand Valley, and Rifle Stations for which the 1975-1976 annual precipitation has been 15.91, 14.66, 12.72, 10.51, and 9.24 inches respectively. Using the Thiessen method 12.95 inches was derived for the C-b Tract. Snow pack was estimated from Little Hills and Altenbern. The Rainfall Frequency Atlas gives the following information for the 10-year and 100-year storms:

10-Year		100-Year	
Duration	Total PPT (in.)	Duration	Total PPT (in.)
30 min.	0.6	1 hr.	1.3
1 hr.	0.9	3 hrs.	1.8
2 hrs.	1.15	12 hrs.	2.6
6 hrs.	1.4		

It is estimated that a 10-year storm was received in June 1975 in the Piceance Basin.

4.2.4 Fugitive Dust

Emission factors for fugitive dust have been estimated by PEDCO 1973. This report formulates an emission factor (E) as:

$$E = 0.27\ (1.068)^{V} + 1.54$$

where E = emission factor (lbs dust/vehicle mile) and V = vehicle speed (mph). This results in sufficient fugitive dust levels along the major access road to the Tract during the construction phase at expected vehicle speeds that the 24-hour particulates

standard is exceeded if no dust controls are applied. Control by watering and/or addition of chemical stabilizers still resulted via computer modeling in fugitive dust levels in excess of the standard. Thus the access road should be paved. The same holds true for major haulage roads.

4.2.5 Lightning Storms

In the summertime frequent lightning storms have caused loss of power in the air quality trailers. The number of these storms from baseline observations is estimated as 12 during late spring and summer months.

4.3 Diffusion Model Inputs

One major use for the baseline meteorological data is for diffusion model inputs. This use really overlaps with monitoring program requirements in that the bulk of modeling inputs are derived from the baseline but data obtained during monitoring provide cumulative additions and supplements to these data.

Prevention-of-Significant-Deterioration regulations require air diffusion computer modeling to demonstrate compliance (currently) for sulfur-dioxide-and-particulate incremental levels in ground-level concentrations caused by the oil shale facilities. These models require inputs of emissions from stacks and fugitive sources and those related to meteorological conditions so as to predict the transport and concentration histories of these pollutants. Model outputs estimate ground-level concentrations of the gaseous or particulate constituent at many hypothetical receptor locations downwind of the emission sources. Modeling is ordinarily done only for "worst-case" meteorological conditions. Worst-case conditions are those, when input to the specified air-diffusion model, yield the highest ground-level ambient concentrations of pollutant at a specified model receptor location for specified input emissions. This is the "local" worst-case for the specified receptor. By examining such concentrations at all model receptor locations, the "global" or overall worst case is obtained. Thus before making any model runs these meteorological conditions are "candidates" for "worst-case." That one-set of meteorological conditions associated with the one, maximum, ground level concentration point is obtained by trial and error from the results of many computer runs utilizing engineering judgment.

Worst-case meteorological candidates depend on atmospheric stability class, mixing layer height (where appropriate), wind speed, wind directional persistence, and time of year. Furthermore, the nature of the "ultimate" computer model itself probably will be dependent on the specific rough terrain of the C-b Tract. Baseline results have shown that the windfield is non-uniform (i.e., wind trajectories are markedly curved). Many computer models assume flat terrain resulting in uniform flow or at best make a two-dimensional terrain correction. Neither assumption is fully justified for the Tract environs. No fully adequate rough terrain model exists; development of one may very well utilize numerically the wind field definition obtained from baseline results. Such development is not in the scope of this report.

The parameters associated with worst-case meteorology have been adequately covered in Chapter 3 but three comments are in order:

1) Worst-case meteorological candidates are cumulative in the sense that a more persistent (in direction) wind might be encountered in the third year of data gathering for a given atmospheric stability class than during the second, etc. Thus the new, more persistent case needs examination. However, the probability of encountering a worst-case, although finite, should diminish as the period of record increases.

2) As was previously pointed out, continuous wind-persistence and atmospheric stability data have been provided from the 200 foot meteorological tower. Effluent stacks may be higher. With a plume rise approximately equal to stack height, the effective stack height could reach as high as 1000 feet. Only special studies (tethersonde and aircraft) yielded data at this height; these were discrete, not continuous studies. Additional data are warranted to assure representativeness; substantial savings in stack height could result, making extra data very cost-effective. Additional data candidates are either tethersonde, or sondes, or pibals equipped with temperature and pressure sensors but <u>not</u> aircraft.

3) Pasquill-Gifford stability classes have been used in diffusion modeling thus far; inasmuch as they apply to flat terrain, better estimation of diffusion coefficients in rough terrain is in order.

4.4 Monitoring Program Guidelines

Another major function of the Environmental Baseline Program is to provide guidance to the next phase, the Environmental Monitoring Program. Guidelines fall into two categories: (1) program design criteria, and (2) specific relationships of Baseline to Environmental Monitoring.

4.4.1 Program Design Criteria

These criteria pertain to (1) the network, (2) instrumentation "weighting," and (3) continuing data requirements.

4.4.1.1 Network Criteria

Because of the extended time period that the Monitoring Program covers and the changing development and operational phases, air quality monitoring must be regarded as dynamic. Number and location of sites, instrumentation, and sampling techniques, and frequencies are subject to change with time inasmuch as it is a scientifically designed program the results of which are subject to on-going analyses and cumulative judgments.

Regarding the criterion of monitor location, general guidelines have evolved from the baseline, from modeling results to date, and from general experience and judgment. These are shown on Table 4-2. They are not mutually exclusive and are often contradictory; therefore subjective judgments in their application are in order.

4.4.1.2 Instrument Weighting Criteria

In terms of baseline experience the instruments utilized can be "weighted" or "scored" according to their demonstrated overall performance. Such weighting criteria are presented on Table 4-3. Scores 1-5 in each category for each instrument and an overall total score have been utilized in the next section to rank the instruments for air quality. A high score is relatively "good," a low score is "bad."

Table 4-2 CRITERIA AND GUIDELINES FOR LOCATING MONITORS

1. Give priority to areas of highest pollutant concentration.
2. Give attention to any densely populated areas.
3. Reflect the quality of the air entering the area (for background comparison).
4. Reflect projected population growth areas, where applicable.
5. Provide site security.
6. Provide site accessibility.
7. Provide power availability.
8. Provide housing of the samplers.
9. Meet legal requirements.
10. Locate on boundary of the Tract, where applicable.
11. Provide best "coverage" for a region.
12. Give attention to national park, refuge wilderness "entrance" (pollution) values, where applicable.
13. Reflect prevailing wind direction, where applicable.
14. Reflect other climatic influences (e.g., snow depth, topography, understory, canopy) where applicable.
15. Reflect proximity to other like monitors.
16. Reflect the requirements of other disciplines (and ecosystem interrelationships).

Table 4-3 INSTRUMENT WEIGHTING CRITERIA

1	demonstrated performance and reliability from the baseline in the Tract environment.
2	accuracy consistent with requirements.
3	measurement necessary to demonstrate compliance with regulations and/or to meet AOSS requirements.
4	direct as opposed to indirect measurement preferred (e.g., measurement by subtraction is less desirable).
5	continuous operation preferred for "representativeness."
6	long wear-out life.
7	sufficient range to cover anticipated operational requirements.
8	availability of detailed calibration and maintenance manual is preferred.
9	overall assessment.

4.4.1.3 Continuing Data Requirements

In this category the following criteria apply:

1) Continuing data are required wherever compliance with standards is required to be demonstrated.

2) Where historical trends from the baseline are indicated (over the relatively short period of record) data gathering is needed. By the same token "flat" parameters might be terminated, spot-checked, or sampled less frequently.

3) Cumulative data from the probabilistic sense as required in some cases (e.g. "worst-case" meteorology).

4) For data exhibiting seasonal, but repetitive trends year after year, sampling might be done only the same season each year.

5) Long-term climatological data are necessary to isolate climate-caused wildlife population changes from population-dependent changes.

6) Data for which one station does not correlate well with that from another station may indicate variability in the field between these stations and suggests continuation of both. On the other hand, for cases where between-station correlations are very high, some elimination of parameters should be investigated.

Program dynamics must reflect unanticipated trends, unexpected impacts, instrument wearout and obsolescence, and changes in air quality standards, both with respect to the number of gases sampled and standards stringency. Increases in availability of data through computerized information systems are needed and desired, perhaps culminating with an on-line environmental-and safety-status system.

4.4.2 Relationships of Baseline to Monitoring

This covers (1) relationships of baseline objectives to monitoring requirements, and (2) sampling method, frequency, and location.

4.4.2.1 Relationships of Baseline Objectives to Monitoring Requirements

Table 4-4 identifies baseline objectives for each meteorological, air quality, and noise category of baseline, the specific section of this report wherein it is discussed, an estimation of the degree to which the baseline objectives were met during baseline, identification of new or continuing data requirements for monitoring and identification of primary parameters needed to satisfy these requirements.

Table 4-4 RELATIONSHIPS OF BASELINE OBJECTIVES TO MONITORING REQUIREMENTS

Area	Category	Baseline Report Section	Baseline Objectives	Degree Objectives Met (%)	New/Continuing Requirements; Data Use	Parameters
Meteorology	Wind Fields	3.1.1	1) Document baseline wind fields	100	Form historical climatological record	WS
			2) Wind persistence by stability class a. Low level (stacks) b. High level	 100 Partial only	"Worst-case" meteorology is a cumulative on-going required statistic over life of project. More high altitude data needed.	WS, WD, Stability @ Effective Stack Height, Wind Dir. Std. Dev.
			3) Station-to-station correlations a. Speed b. Direction	 Partial 100-limited sample	Numerical wind field modeling for diffusion model using data from 1)	 WS WD
			4) Supporting data for air quality	100	Continuous requirement	WS,WD
			5) Peak wind design criteria	100	A continuing requirement prior to design	Max WS
	Temperature Fields	3.1.2	1) Document baseline temperature fields	100	Form historical climatological record	T
			2) Vertical temp. structure for atmospheric stability a. Low level b. High level	 100 Partial only	"Worst-case" meteorology is a cumulative on-going required statistic over life of project. More high altitude data needed.	T, dT/dz, Inversion Height
	Other Meteorology	3.1.3	Supporting Data	100 except for ppt	Historical climatological record	P, Solar Rad., RH, Ppt
Air Quality	Gaseous & Particulate Concentrations	3.2.1., 3.2.2	1) Document baseline air quality	100	Continuing requirement on compliance checks with standards; SO_2, TSP control system effectiveness and diffusion model checks; ecosystem interaction studies.	SO_2, H_2S, TSP, THC, CH_4, NMHC, NO_x, NO, NO_2, O_3, CO
			2) Initiate long-term trend analysis	100	Continuing requirement	SO_2, H_2S, TSP, THC, CH_4, NMHC, NO_x, NO, NO_2, O_3, CO
		3.2.3, 3.2.4	3) Attempt to correlate with meteorological data to identify emission sources	Partial	More in-depth ozone transport analysis. Bio-analysis and chemical analysis of terpenes from sagebrush. Additional analysis of fugitive nature of TSP.	Primarily TSP, NMHC, O_3
	Hazardous Materials	3.2.6	1) Establish baseline concentrations	100 except arsine	Continuing requirement. Arsine needs improved measurement techniques.	H_2S, Arsine, Particulate Arsenic, Mercury, possibly Selenium
	Area-Wide Visibility	3.2.7	1) Establish baseline visibility	100	Periodic annual checks for long-range trend analysis.	Visual range
Noise	Noise	3.3.1	1) Obtain traffic noise levels	100	Monitor traffic noise	Noise intensity level
		3.3.2	2) Provide noise level measurements in vicinity of C-b Tract	100	Monitor Tract noise for compliance with a continuous recorder.	Noise intensity level

The justification for a long-term historical climatological record may be illustrated through the following example. It is very important in this endeavor to attempt to sort out the climatic effects on populations of important species found in the Tract from effects which might otherwise be attributable totally to man. Watt 1973 states that how much a population fluctuates due to weather depends upon the interaction of two factors: the magnitude of fluctuations in weather and sensitivity of the species to that degree of weather fluctuation. If weather fluctuates only a small amount and the species is insensitive to weather fluctuations, then this is the circumstance under which the relative importance of population density dependence as a regulatory mechanism will be maximal. The greater the sensitivity of the species to fluctuations in the physical environment, and the greater the amplitude of those fluctuations, the more important density-independent mechanisms will be in relation to density-dependent mechanisms in modifying trends in the species population. Putting it in different language, the importance of endogenous factors relative to exogenous factors as regulators of biomass through time increases with increasing suitability of the environment. This complex problem requires observation of both climatology and of populations of species of local importance over an extended period of time to unravel it.

As mentioned in Section 4.3, because of the rough terrain the wind fields have been found to be non-uniform (i.e., the wind direction is not in a straight line). Therefore, in all probability the next generation computer model for air diffusion may possibly be a numerical wind field submodel (tailored specifically to the C-b site) which drives an analytical or quasi-analytical diffusion model. Therefore the correlation of wind speed and direction at many points to that of a reference point (the meteorological tower) is needed.

Under the category of "other meteorology," precipitation data collected at the air quality stations (and reported in Volume II) have only been partially successful for two reasons: 1) precipitation gauge power was obtained from the trailer; whenever trailer power was temporarily out the gauge was off so that cumulative precipitation totals were low; 2) in the wintertime loss of trailer power meant loss of power to the gauge's heater (to melt the snow). This loss caused the tipping-bucket gauge to freeze compounding the first problem.

Regarding gaseous and particulate concentrations, continuing requirements exist for monitoring to show compliance with National Ambient Air Quality Standards and with Colorado Ambient Standards. Averaging times vary from one-hour to three-hour, eight-hour, twenty-four-hour and annual depending on the constituent.

Ambient measurements of ambient air quality downwind of the oil shale facility stacks will be used to obtain a check on the diffusion model results. In this regard the diffusion model generates isopleths or pollution contours as a geographical pattern which are superimposed on a map of the C-b Tract. The incremental pollutant concentration is "picked-off" at the location of each trailer and added to the background level obtained from the baseline studies. A comparison is then made to the value recorded at the trailer under corresponding meteorological conditions.

Furthermore, ecosystem interaction studies need identification of geographical areas (for "control" plots) which are pollution free as well as those located in areas of relatively high pollutant concentrations. Although these interactions are the subject of Volume V, it is the above-referenced modeling studies that provide the isopleths which will help locate geographical areas for controls.

Regarding possible identification of emission sources (off-Tract, primarily), it is mainly within the purview of the EPA and State via regional monitoring systems to perform such source identification, particularly where preliminary analysis has indicated that sources are the result of long-range transport. This possibility exists in the cases of ozone and non-methane hydrocarbons. Continuing analysis of all the gaseous constituents on the Tract is warranted, including that of between-station correlations which at this time are only partially understood. The "troublesome" constituents with regard to meeting standards have proven to be particulates, ozone, and non-methane hydrocarbons. Therefore it behooves us to attempt to verify that terpenes do or do not cause the high methane hydrocarbon readings at Station 023 by chemical analysis of sagebrush and by independent air quality sampling to establish the nature of the hydrocarbons. Such sampling can also serve as a check on the relatively inaccurate present NMHC instrument itself. Regarding ozone additional data and analyses are needed to substantiate the ozone transport hypothesis set forth and partially documented during baseline so as to isolate probable source with each high-ozone event. Keeping track of the $NMHC/NO_x$ ratio assists in determining probability of local vs. non-local origin depending upon its numerical value during or just prior to the high-ozone event. Regarding particulates, the fugitive nature of particulates at the Tract is reasonably well documented but further analysis and sampling are warranted during the monitoring phase.

Continued monitoring for hazardous materials is warranted. Volatile trace metals - selenium, arsenic, particulate arsenic, and mercury were monitored during baseline. The technique for arsine utilized is still regarded as "R&D" and needs to be pursued by the EPA for improved accuracy. Since arsenic is expected

to be found as a product of shale oil, its monitoring should continue, pending development of an adequate sampling method.

Visibility is a term reasonably well understood by the general public and, as such, is a measurement whose long-term trend should be maintained by periodic sampling at major operational phases.

Regarding noise, the baseline measurements were discrete at low frequency. Continuous measurements at selected locations on each Tract boundary are needed.

4.4.2.2 Sampling

Tables 4-5a and 4-5b present the sampling method, frequency, and number of locations during baseline and, as advocated, during monitoring along with reasons for the changes. Some examples from these tables will be highlighted.

Utilizing the criteria given in Table 4-3 all the air quality instruments used in the trailers during baseline have been relatively ranked and presented on Table 4-6. Some insights as to the rankings follow.

The SO_2 instrument is reliable and its installed accuracy was demonstrated via side-by-side tests to be consistent with the manufacturer's specification. However, most measurements during baseline have proven to be at or below its minimum detectable limit. Furthermore, prevention-of-significant-deterioration regulations require SO_2 increments no higher than the demonstrated accuracy of this instrument. Thus its accuracy "score" is low. By the same token current maximum instrument range probably won't be needed. An improved accuracy instrument with smaller range is indicated.

Regarding H_2S the same argument as for SO_2 applies but to a lesser extent. In ppb the accuracy is the same but in micrograms per cubic meter it is relatively better for H_2S. At present there are no PSD regulations for H_2S. The instrument is deemed to be satisfactory.

Regarding NO_x the specific Meloy instrument's pump was developed for near-sea-level operation; at a 7000 foot elevation, when adjusted to operate satisfactorily, it induces "noise" into the instrument. A "fix" here will be investigated to try to match the pump to the altitude. Otherwise the instrument is satisfactory and its continued use advocated.

Table 4-5 DATA USE AND SAMPLING DURING ENVIRONMENTAL MONITORING
a. Air Quality

DATA USE		SAMPLING METHOD			SAMPLING FREQUENCY			NO. SAMPLING LOCATIONS		
		Baseline	Advocated	Reason	Baseline	Advocated	Reason	Baseline	Advocated	Reason
a) STATUS										
b) COMPARISON WITH STANDARDS	SO_2	Flame photometric	Same		1/sec.	1/sec.	All automated; compliance with standards	5	4	1) Monitor Piceance Creek access and corridor emissions for ambient compliance 2) Monitor Tract emissions for ambient compliance 3) 1 location for pristine conditions for all wind sectors; 1 @ maximum concentrations 4) Preserve continuity with baseline
	H_2S	Flame photometric	Same		1/sec.	1/sec.		5	4	
	Particulates	High-volume	Same		1/24 hr.	1/24 hr.		5	4	
	NO_x	Chemiluminescent	Mod. pump	Instrument noisy at alt.	1/sec.	1/sec.		2	2	
	NO	Chemiluminescent	Mod. pump	Instrument noisy at alt.	1/sec.	1/sec.		2	2	
	NO_2	NO_x-NO	Same		1/sec.	1/sec.		2	2	
	O_3	Chemiluminescent	Same		1/sec.	1/sec.		2	2	
	THC	Gas Chrom.	Gas Chrom.		5 min.	5 min.		2	2	
	CH_4	Gas Chrom.	Gas Chrom.		5 min.	5 min.		2	2	
	NMHC	THC-CH_4	Open	Subtraction not accurate	5 min.	5 min.		2	2	
	CO	Gas Chrom.	Consider sep. inst.	Subtraction not accurate	5 min.	5 min.		2	2	
c) LONG TERM TRENDS		As above	As above		Annual average	Annual average	Sufficient for long term	As above	As above	
d) POLLUTION CONTROL SYSTEM EFFECTIVENESS	SO_2	As above	As above		1/sec.	1/sec.	Continuous monitoring required	-	As above	Monitor compliance
	Particulates				1/24 hr.	1/24 hr.				
e) ATTEMPT TO ESTABLISH SOURCES FOR HIGH BACKGROUND	Particulates	As above	As above		1/24 hr.	1/24 hr.			4-5 C-b + EPA regional	EPA regional interface needed
	NMHC	As above	+ Chem. anal.	Also bio. analysis of sage	5 min.	Open	Identify terpenes			
	O_3	As above	As above		1/sec.	1/sec.				
f) MONITOR HAZARDOUS CONSTITUENTS	H_2S	As above	As above + wet chem.	Additional monitoring at selected locations	As above	As above +		As above	As above + selected	
	Arsenic		Open	R&D status	1/qtr.	1/qtr.		1	1	
	Mercury				1/qtr.	1/qtr.		1	1	
g) VISIBILITY STATUS AND TRENDS		Photometry	Photometry	Satisfactory	1/6 days	1/6 days	Periodically, during operations	1	1	Same as baseline to preserve continuity

Table 4-5 DATA USE AND SAMPLING DURING ENVIRONMENTAL MONITORING
b. Meteorology and Noise

DATA USE		SAMPLING METHOD			SAMPLING FREQUENCY			NO. SAMPLING LOCATIONS		
		Baseline	Advocated	Reason	Baseline	Advocated	Reason	Baseline	Advocated	Reason
a) METEOROLOGICAL SUPPORT FOR AIR QUALITY	Wind Speed	Anemometer	Same	Technique satisfactory	1/sec.	1/sec.	Same frequency required as for air quality	5	4	Same locations as for air quality
	Wind Direction	Vane	Same	Technique satisfactory	1/sec.	1/sec.		5	4	
	Temperature	Thermister	Same	Technique satisfactory	1/sec.	1/sec.		5	4	
	Relative Humidity	RH Sensor	Same	Technique satisfactory	1/sec.	1/sec.		5	4	Cut RH on tower to 2 levels
	Pressure	Barometer	Same	Technique satisfactory	1/sec.	1/sec.		2	2	
b) DIFFUSION MODELING INPUT	Wind Speed	Anemometer	Same	Satisfactory	1/sec.	1/sec.	Continuity with baseline	1- 200' Tower	1- 200' Tower	
	Wind Direction	Vane	Same	Satisfactory	1/sec.	1/sec.				
	Solar Radiation	Pyranometer	Same	Satisfactory	1/sec.	1/sec.				
	Temperature Diff.	Thermister	Same	Satisfactory	5 min.	1/sec.				Continue stability data for low level releases
	Wind Direction Std. Dev.	Vane; tethersonde	Same	Satisfactory	Sounder-continuous	5 min.				
	Inversion Height	Acoustic sounder; A/C, tethersonde	Acoustic sounder tethersonde or T-Sonde	Eliminate A/C - expensive and not representative	1 10-day test	2 T-Sonde per day every other day	Need stability data for high level releases	2 2-Tethersonde	2 1-T-Sonde	Needed on plateau and in creek Tower location has been used for low level stability
c) WIND FIELD DEFINITION	Wind Speed	Anemometer	Same	MRI satisfactory if effort devoted to attain reliability	Trlr-1/sec.	Same	Continuity with baseline	5-Trlr	4-Trlr;	Move MRI to roundout locations @ ~ 3 months per location
	Wind Direction	Vane	Same		MRI -1/hr.	Same		3-MRI	1 movable MRI	
	Temperature	Bimetal coil				Same				
d) TRAFFIC NOISE		Sound level meter; traffic count	Same	Satisfactory	1/mo.	1/mo.	Satisfactory; State needs periodic traffic surveys	1 in Piceance Creek; 1 on access road; 13 for traffic survey	Same	Satisfactory; of general interest to continue
e) TRACT-GENERATED NOISE SURVEILLANCE		Sound level meter	Continuous recorder	Baseline techniques inadequate	1/mo.	Continuous for 24-hr. every 6th day until ops; then every day	Intensity and dose needed for compliance with standards	14	4	1 needed along each Tract border

Table 4-6

BASELINE RELATIVE AIR-QUALITY INSTRUMENT WEIGHTING
(0 to 5; High Score is Best)

CONSTITUENT	PRINCIPLE	RELATIVE SCORE BY CRITERIA NO.										REL. RANK
		1	2	3	4	5	6	7	8	9	Composite	
		Performance & Reliability	Accuracy	Required by Standards or Lease	Direct Measurement	Continuous	Long Wearout Life	Range	Calibration & Maint. Manual	Overall Assessment	Total Score	
SO_2	Flame Photometric	5	1	5	5	5	5	1	5	3	35	4
H_2S	Flame Photometric	5	2	5	5	5	5	2	5	4	38	2
TSP	Filtering	5	3	5	3	3	5	5	1	5	35	3
NO_x	Chemiluminescent	2	2	5	5	5	4	3	5	2	33	5
NO	Chemiluminescent	2	2	5	5	5	4	3	5	2	33	6
NO_2	NO_x - NO	2	2	5	0	5	4	3	5	2	28	7
O_3	Chemiluminescent	5	5	5	5	5	5	5	5	5	45	1
THC	Gas Chromatography	1	4	5	5	4	2	3	3	1	28	9
CH_4	Gas Chromatography	1	4	5	5	4	2	3	3	1	28	8
NMHC	THC - CH_4	1	0	5	0	4	2	3	3	1	19	11
CO	Gas Chromatography	1	2	5	1	4	2	3	3	1	22	10

Regarding non-methane hydrocarbons, they are obtained as the sometimes small difference between two large numbers: total hydrocarbons and methane. Thus it is relatively inaccurate. No viable alternative is evident at this time but a continuing assessment will be made. Investigation of obtaining CO as a separate measurement should be undertaken to improve its accuracy. In addition the gas chromatograph was the most difficult of all the instruments to keep in continued operation; therefore all its derived gaseous species were scored low. However the imperative case for continued measurement of hydrocarbons has already been made.

The ozone instrument was scored highly because it was operationally the best of all the instruments and its continued use is warranted.

Chemical analyses for four 24-hour samples per month during the summer for a breakdown of possible terpene-related hydrocarbons and a biochemical analysis of sagebrush at the same time are suggested.

Some interface with the EPA on a regional basis is necessary to pursue points of origin of ozone and hydrocarbon precursors in addition to our own continuing analysis.

Regarding meteorological considerations on Table 4-5b both the acoustic sounder and mechanical weather stations provide valuable information when working properly; experience has shown both need almost daily attention in the harsh C-b environment, notwithstanding claims of the respective manufacturers. Obtaining total (annual) precipitation from instrumentation dependent on power from the trailers proved to be unreliable due to infrequent loss of trailer power coupled with attendant freeze-up of the gauge heater element. Two manual gauges have been installed at Stations 023 and 020 and their continued high-reliability operation is advocated.

Data representativeness has proven important in the meteorological sense. For example, upper air studies were conducted utilizing aircraft for four quarters with 15 flights per quarter. Comparisons with continuous acoustic sounders showed that the frequency of atmospheric inversions and their expected height were "representative" as obtained from aircraft data in only one of four quarters; thus a change of technique is clearly indicated suggesting that aircraft flights be no longer used. T-Sondes instrumented with temperature and pressure sensors or utilizing double theodolite tracking are suggested as substitutes.

Although redundancy from a reliability standpoint is good, on the tower at three levels through the baseline there have been both vane anemometer and bivane combinations. One set could be

eliminated in the next phase.

A spot check on differences in relative humidity at four levels on the tower has indicated as much as 6 percent relative humidity difference between 8 feet and 200 feet which seems to warrant at least measurement of that quantity at least two levels on the tower; four levels are not necessary.

Although it is not the province of this document to firmly select station locations for the next phase, the following considerations should be entertained to establish the number of stations. Four stations are required under the lease stipulations. Baseline Stations 021 and 022 in Piceance Creek might be considered to be discontinued since flow there has been demonstrated to follow the general direction of the creek-bed and can be monitored adequately by continuing operation of the heavily-instrumented Station 020 through the plant operations phase. On the other side of the coin, Station 021 has exhibited the coldest temperatures of the entire local C-b Tract region on two successive winters coupled with the most intensive ground-based inversions and horizontal temperature gradients. It is possible that such conditions might lead to high pollutant concentrations from vehicular traffic, particularly during the construction phase when manpower levels peak.

Station 020 is expected to be exposed to heavy concentrations from vehicular exhaust in the main Piceance Creek access corridor. Added justifications for its use are 1) the big difference in NMHC, which exceeded standards, at Stations 023 and 020, and 2) it is intuitively expected to be near the off-Tract point of maximum concentrations for F stability reflecting containment of the flow by the valley walls.

Station 023 on Tract near the center of the proposed operational plant-complex is the most heavily instrumented trailer in that it is co-located with the 200-foot meteorological tower and contains all its data channels. It is definitely needed for continuity with baseline and suspension monitoring since it was the only station operating during this time period. Its instrumentation accuracy is verified by continuing EPA audits.

Station 024 should continue operation at the expected on-Tract point of maximum pollutant concentrations for A stability for the south-southwest predominant wind direction from the plateau. Its exact location will be estimated from modeling studies now underway. It could change location between the ancillary and full scale operational phase because of markedly different stack locations.

A new Station, 026, south of the Tract could serve a dual role - practically all the time it would be serving as a "pristine" ambient reference since predominant wind direction on the plateau is SSW; however, one potentially worst-case condition from plant-induced emissions occurs for northerly winds, so in this case it would monitor these downwind concentrations at their estimated maximum point. One must keep in mind that maximum ground level concentrations can be "rare" events bearing little resemblance to prevailing winds; the guiding criteria are wind persistence (over a short span of the day) and stability class.

Inasmuch as the MRI mechanical weather stations provide good, relatively inexpensive data, the operation of at least one site, moved every three months to a new location, is advocated to obtain inter-station near-surface windfield correlation data for the numerical windfield model.

As a group the following benefit from several-station networks: 1) the potential numerical model of the windfield, 2) variability in levels of SO_2 and H_2S between stations indicates possibility of low-level sources near the Tract, 3) variability in levels of NMHC (already mentioned), and 4) use of air quality stations to verify future air diffusion models.

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APPENDIX A

A.1 Radian Air Quality and Meteorological Data

A.1.1 Methodology

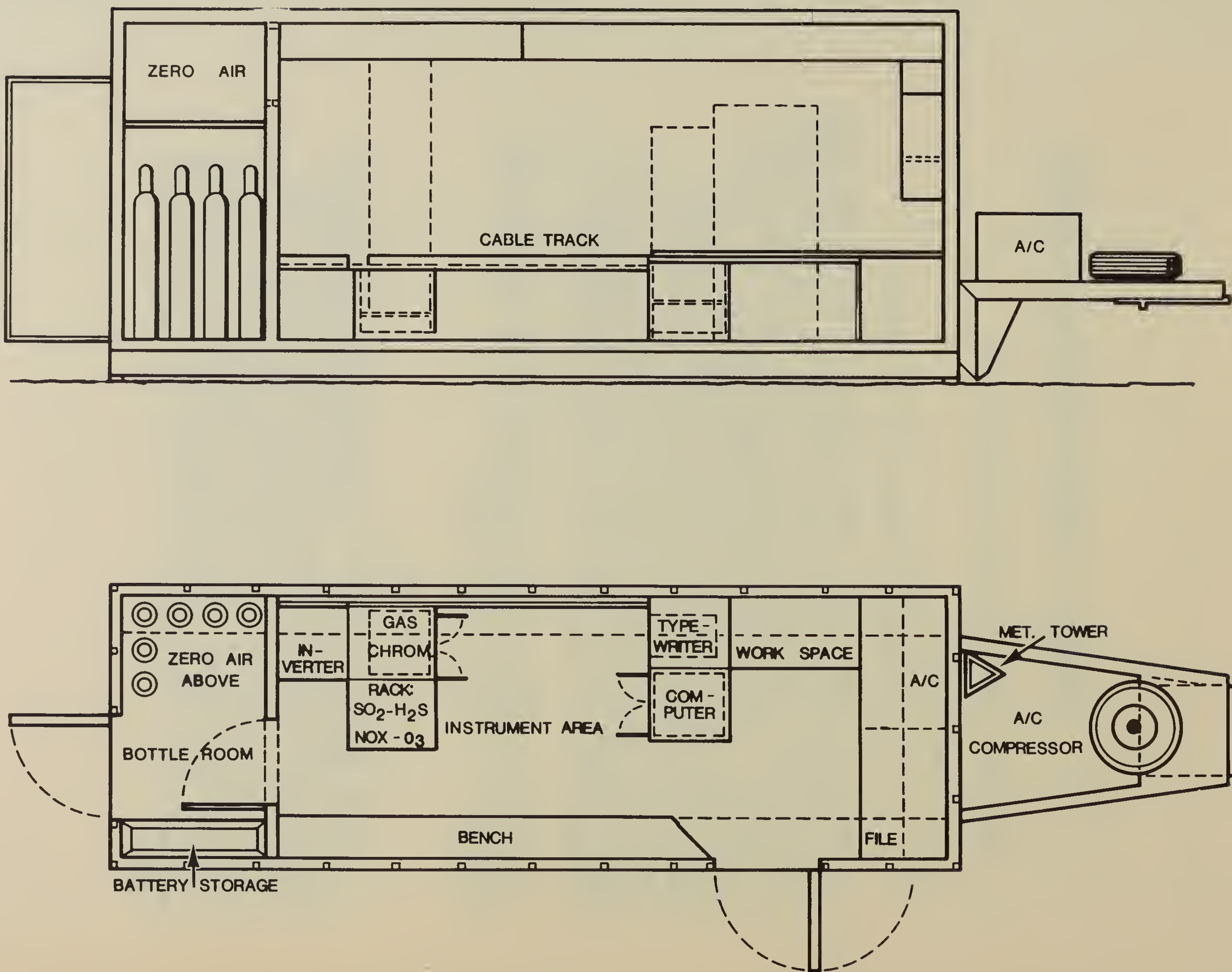
A.1.1.1 Sampling Techniques for Air Quality

The Radian Corporation provided ambient air quality monitoring at five sites over the entire two year baseline. The five trailer sites designated Stations 020, 021, 022, 023, and 024 are located on Figure 2-2. Each site measures and records the concentration of particulates, sulfur dioxide, and hydrogen sulfide. In addition, two of the sites record the amounts of nitrogen oxides, total hydrocarbons, methane, ozone, and carbon monoxide. Selected meteorological parameters such as wind speed, wind direction, temperature, and rainfall are monitored at each station. A 200-foot meteorological tower at one of the sites provides meteorological information as a function of height. Meteorological instrumentation is mounted at the 8, 30, 100, and 200-foot levels.

Figure A-1 shows a typical configuration of each monitoring station. The station enclosure provides a sturdy and protective covering for the monitoring equipment.

A.1.1.1.1 SO_2 and H_2S

Sulfur dioxide and hydrogen sulfide are both measured with Meloy Model SA185-2 analyzers. These analyzers use the flame photometric detection principle (hydrogen-air flame), and have a fixed full-scale range of one part per million (ppm). The minimum detection limit is 0.005 ppm; the accuracy is ±1 percent of full-scale; and the 24-hour zero or span drift is ±1 percent of full-scale (maximum). The analyzer output is continuous and is routed to an analog-to-digital voltage converter which is in turn sampled by the Data General Nova 1200 minicomputer in each trailer.



AIR QUALITY TRAILER LAYOUT

FIGURE A-1

A.1.1.1.2 Ozone

Ozone is measured continuously by a Meloy Model 0A350 analyzer based on the chemiluminescent principle (ozone-ethylene reaction). This analyzer is operated on a full-scale range of 0.5 ppm and has a minimum detection limit of 0.0005 ppm. The accuracy is ±1 percent of full-scale, as is the maximum zero or span drift.

A.1.1.1.3 Nitrogen Oxides

Nitrogen oxides are measured with a Meloy Model NA520 chemiluminescent analyzer. This is a dual channel analyzer which continuously measures both nitrogen oxides and nitric oxide. Nitrogen dioxide is continuously obtained as the difference between these two channels. The analyzer is operated on a full-scale range of 0.5 ppm. The accuracy is ±1 percent of full-scale; the minimum detection limit is 0.005 ppm; and the maximum 24-hour zero and span drift is ±1 percent of full-scale.

A.1.1.1.4 Methane, Total Hydrocarbons, Carbon Monoxide

A Bendix Model 8200 gas chromatograph with flame ionization detector is used to monitor methane, total hydrocarbons, and carbon monoxide. A discrete air sample is collected and analyzed once every five minutes. Non-methane hydrocarbons are determined as the difference between the total hydrocarbons and methane.

The minimum detection limit is well below natural background levels of methane and carbon monoxide. Total hydrocarbons, methane, and carbon monoxide are normally operated on a full-scale range of 5 ppm. Noise, accuracy, and 24-hour drift are a maximum of 1 percent of full-scale.

A.1.1.1.5 Particulates

Particulates are measured with high volume samplers. The metal shelter is built by Radian Corporation, and the sampling head and motor are built by General Metal Works. The air flow recorder is built by Dickinson. Fiberglass filter paper is used for collection of particulates and is equilibrated in a constant humidity chamber before weighing. A Torbal Model EA-1AP balance is used for weighing the filters. Each Hi-Vol has a flow recorder to permit correction for changes in air flow as the filter becomes loaded with particulates. Each Hi-Vol runs for a 24-hour period (midnight to midnight), and is turned on and off by the trailer computer. The Hi-Vols were designed following guide-lines recommended by the Environmental Protection Agency.

In addition to the normal Hi-Vol particulate samples, a duplicate Hi-Vol sample was collected every sixth day in the first year of baseline on special filter paper for trace element analysis. Once each quarter these samples were composited and analyzed for gross radioactivity and trace element content.

A.1.1.1.6 Air Intake Manifold

The air sample for all of the analyzers, except the particulate samplers, is drawn in through a 25 mm-diameter glass-cane and manifold system. The intake is approximately 12 feet above ground level. Once inside the shelter, the entire manifold is heated to prevent condensation of water vapor. A 60 cubic-foot-per-minute fan is mounted downstream of the sample ports and is vented to the outside of the trailer. Sensors measure both up- and downstream of the manifold and trigger an alarm on a status panel if either falls below a preset limit.

A.1.1.2 Sampling Techniques - Trailer Meteorology

Four of the ambient air monitoring trailers (020, 021, 022, 024) are equipped with the following meteorological instrumentation: (1) dry bulb temperature (outside), (2) relative humidity, (3) wind direction, (4) wind speed, and (5) a tipping bucket, heated rain/snow gauge. Trailer 024 is also equipped with an analog barometer for measurement of barometric pressure. The temperature probe and relative humidity sensor are mounted inside a motor aspirated radiation shield, the Model 1S6 Aspirated Radiation Shield by Weather Measure, which gives an aspiration of approximately 100 cfm. The wind instrumentation and temperature and relative humidity apparatus (in the aspirated radiation shield) are all mounted atop a 33-foot crank-up meteorological tower (the WM-33, by Weather Measure) at each of the four trailer sites. Meteorological instrumentation at Trailer 023 is discussed under Tower Meteorology.

The wind instrumentation at the monitoring trailers consists of the Model W103/3L Lightweight Cup Anemometer by Weather Measure and the Model W104-2 Lightweight Vane by Weather Measure. The anemometer is a high response, low threshold wind system which offers the optimum in versatility and economy. For low-threshold applications, a unique frictionless tachometer employing a high frequency oscillator and receiver is used to measure precisely wind speed. The oscillator, transmitter, and receiver are encapsulated in a small cube of epoxy for total protection against the environment.

The solid state tachometer is essentially free from maintenance with a life of well over five years when operated continuously. The specifications of the W103 Cup Anemometer are as follows:

- Accuracy: ±1 percent or .15 mph, whichever is greater.
- Bearings: Sealed and shielded precision stainless steel.
- Threshold: 0.6 miles per hour.
- Distance Constant: 5 feet.

The wind vane, the W104-2, is equipped with a 1000 ohm low torque potentiometer and two wipers for 0^{0} to 540^{0} operations. The response characteristics of this vane are:

- Dead Band: 0 degrees.
- Damping Ratio: 0.4.
- Distance Constant: 3.5 feet.
- Threshold: 0.75 miles per hour.
- Potentiometer Linearity: 0.5 percent.

The thermistor probe used in the motor aspirated radiation shields is the Model T621-TP18X Air Temperature Premium Thermistor Probe by Weather Measure. This probe has a range of $-50^{0}C$ to $+50^{0}C$ and an interchangeability of $\pm 0.055^{0}C$. The output signal accuracy is $\pm 0.3^{0}F$.

The relative humidity sensor is the Model 2013 Remote Reading Relative Humidity System by Texas Electronics. The sensor assembly contains a newly-developed hygroscopic inorganic sensing element. Its expansion and contraction positions the suspended core of a linear variable differential transformer (LVDT). The absence of friction inducing linkages and wiping contacts minimizes hysteresis and improves accuracy. The LVDT output signal, when processed, is directly proportional to relative humidity. The specifications of this instrument are as follows:

- Range of Indication: 0 percent to 100 percent RH.
- Response: The sensor response time to a step change of 10 percent in relative humidity is less than two minutes with the sensor exposed to moving air.
- Accuracy: 5 percent - 15 percent RH; ±5 percent RH
15 percent - 95 percent RH; ±2 percent RH
95 percent - 100 percent RH; ±3 percent RH

- Signal Output: Analog signal of -150 mv. to +150 mv. with electrical zero at 50 percent RH is standard.

Each of the five monitoring trailers is equipped with a model P511-E Remote Recording Heated Snow gauge by Weather Measure. In the case of this gauge, the durability and reliability of a tipping bucket gauge are combined with heavy-duty electric heaters to make this an all-purpose precipitation sensor. This gauge may be used to measure snowfall and rainfall. An insulating cover of poly-vinyl chloride and thermostatic control insure the proper gauge temperature. The thermostatic control is adjustable from 0 to 35°C. Snow falling into the inlet funnel is melted. The resulting water (from rain or snow) drains into a precision tipping bucket mechanism which activates a mercury switch each time the bucket fills and tips. The gauge is constructed of durable corrosion-resistant materials to provide many years of service. The specifications of this gauge are as follows:

- Orifice: 8 inches.
- Calibration: 0.01 inch.
- Accuracy: 0.5 percent (Calibrated at 0.5 in/hr).
- Sensor: Chrome plated tipping buckets.
- Switch: Mercury, 0.1 second closure.
- Heat Control: Thermostat adjustment, 0 to 35°C.

The barometer at Trailer 024 is the B242 Analog Output Barometer by Weather Measure. This barometer provides an output voltage that is linearly proportional to pressure. The specifications on this sensor, which is mounted inside Trailer 024, are:

- Range: Specifically designed for the 100-millibar interval from 750 millibars to 850 millibars.
- Resolution: Infinite.
- Linearity: ±0.5 millibar, over the 100-millibar interval.

A.1.1.3 Sampling Techniques - 200-Foot Meteorological Tower

The tower has instrumentation at four levels: 8 feet, 30 feet, 100 feet, and 200 feet. At all four levels, there are: wind speed, wind direction, and temperature and relative humidity sensors in a power aspirated radiation shield. Temperature difference thermistors

(also in power-aspirated radiation shields) and their associated circuitry take lapse-rate measurements for the 30-foot to 100-foot layer and the 30-foot to 200-foot layer. Since January 1975, the tower has been equipped with Gill Anemometer Bivanes by R. M. Young at the 30-, 100-, and 200-foot levels. In addition, this site has a Precision Spectral Pyranometer, a barometer, and a tipping bucket rain/snow gauge.

The wind direction and speed apparatus used at each measurement level of the tower is the Model 1074-2 wind sensor by Meteorological Research, Inc. (MRI). This sensor has a 540^0 potentiometer for wind direction and a light chopper for wind speed. This sensor is rugged, with an all-weather coaxial cup and damped vane assembly. The prototype model has been in operation for years under the most demanding weather conditions, performing continuously with the utmost reliability. All of the wind sensors on the tower have been specially treated with a black paint which will promote warming of the exposed surfaces of the sensor and thereby reduce ice and snow accumulations on the moving parts of the apparatus. The specifications on the Model 1074-2 are as follows:

Wind Speed

- Starting Threshold: 0.75 mph.
- Response Distance: 18 feet (63 percent recovery).
- Flow Coefficient: 7.9 feet/Revolution.
- Accuracy: ±0.4 mph or 1 percent (whichever is greater).

Wind Direction

- Starting Threshold: 0.75 mph.
- Delay Distance: 4 feet (50 percent recovery).
- Damping Ratio: 0.5 to 0.6.
- Accuracy (540^0 system): ±1 percent.
- Range: 0^0 to 540^0.

The relative humidity and temperature sensors are mounted within a power aspirated radiation shield at each tower level. All aspirators and sensors are of the Model 840 Series by MRI. The aspirated, shielded housing is designed to provide maximum radiation protection to the sensor. Ambient air is drawn into the shield and across the sensors at approximately 15 feet per second. This intake air is essentially sampled from a hemispherical space which is approximately a three-inch radius from the

tube opening. Speed of the incoming air at the periphery of this hemisphere is approximately 1 mph.

The temperature sensor is comprised of a dual thermistor and resistor network. This circuit provides a linear resistance change with an air temperature change. The relative humidity sensor is placed alongside the temperature elements inside the shield where it is exposed to a constant flow of air. Circulation to both sides of the sensing element produces accurate monitoring with a good response time. The specifications on the sensing elements are as follows:

<u>Temperature</u>

- Accuracy: $\pm$ 0.25^{0}C
- Range: -50^{0}C to +50^{0}C

<u>Humidity</u>

- Accuracy: $\pm$ 3.0 percent RH
- Range: 0 percent to 100 percent Relative Humidity

Measurements of temperature difference are taken for two layers, the 30-foot to 100-foot and the 30-foot to 200-foot layer. The thermistors and circuitry used for these measurements are separate from the thermistors measuring air temperature. The use of separate thermistors and circuitry to measure ΔT allows for much greater accuracy and resolution in the measurements, which is necessary for stability assessments. Two ΔT thermistors are at the 30-foot level, one is at the 100-foot level, and one is at the 200-foot level. All of these ΔT thermistors are mounted within power aspirated radiation shields. The specifications on the ΔT instrumentation are as follows:

- Accuracy: $\pm$0.1^{0}C
- Range at ΔT Circuit
  (Lower Level-Upper Level): +9^{0}F to -9^{0}F

Model 21002 Gill Anemometer Bivanes, produced by the R. M. Young Company, have been operating at the 30-, 100-, and 200-foot levels since January 1975. These instruments, which are very sensitive, have been used to measure the vertical and horizontal directional components of the wind as well as the standard deviations of these wind directions. The bivane wind speeds have provided a backup for the standard wind speed sensors at those levels. The specifications on the anemometer bivane are as follows:

- Range: 0-540^0 azimuth.
  ±50^0 elevation.
  0-100 miles per hour.

- Threshold: vane, 0.3 to 0.5 miles per hour.
  4-blade propeller: 0.3-0.5 miles per hour.

- Delay distance: 3.1 feet for 50 percent recovery of vane.

- Distance constant of 4-blade propeller: 3.1 feet.

All instrumentation, except at the ground level, is mounted at the end of 12-foot retractable booms. These booms are 3-inch box beams which are on rollers and can be retracted to the instrument platforms for instrument maintenance.

The meteorological tower itself is a 200-foot Rohn Model 80 Guyed Tower, designed for 40 pounds per square foot wind load with ½" of radial ice per EIA Standard RS-222-B, to support four levels of meteorological equipment. The material consists of tower sections with a tapered base, three retractable booms 12-feet long, three outside work platforms, an inside ladder for climbing, two base ground kits and one anchor ground kit. The cable-type safety climbing device consists of a cable and attachment mechanisms with a locking sleeve and safety belt. The tower is lighted and painted according to FAA specifications.

The signals from the tower instrumentation are fed from multiple signal cables into transmitters mounted at the base of the tower. After signals have been converted to analog signals, they are fed into a junction box, also at the tower base, where they are assimilated into one coaxial cable. The signals are then run underground within 3" PVC conduit to the A-to-D assembly at Trailer 023 where they are processed. The transmitters are shielded and insulated from the elements. The signal cable is run underground in PVC conduit in order to minimize the damage from the weather or various rodents in the region.

The auxiliary equipment at the tower site consists of a heated tipping bucket rain/snow gauge, an analog barometer, and a Precision Spectral Pyranometer, all processed in Trailer 023. The rain/snow gauge is the Model P511-E unit by Weather Measure, with characteristics and specifications as previously described. The barometer is the B242 Analog Output Barometer by Weather Measure. This barometer provides an output voltage that is linearly proportional to pressure. The specifications on this instrument, which is mounted inside the monitoring trailer at the site, are as follows:

- Range: Specially designed for the 100 millibar interval from 725 millibars to 825 millibars.

- Resolution: Infinite

- Linearity: ± 0.5 millibar, over the 100 millibar interval.

The pyranometer at the site is the Eppley Precision Spectral Pyranometer. This instrument is used for the measurement of sun and sky radiation totally or in defined wavelength bands. The pyranometer is levelled and mounted atop a wooden stand 4½ feet from the ground surface. Care has been taken to eliminate the effects from all outside influences, such as reflection or shadows, on the pyranometer. The instrument characteristics are as follows:

- Sensitivity: 5 mv. per $cal/cm^2/min$

- Independence: 300 ohms

- Temperature dependence: Sensitivity constant to within ± 1 percent over the ambient temperature range from -20 to +40^{0}C

- Linearity: Response linear up to intensities of 4 $cal/cm^2/min$

- Response Time: 1 second (i/e signal)

A.1.1.4 Data Sampling

The output of all the analyzers except the particulates and all meteorological instrumentation is converted to a digital voltage. The minicomputer in each trailer samples each data channel once per second and calculates and stores five-minute averages from the one-second readings. Once per hour the five-minute averages are stored on two cassette tapes and printed out on hard copy. These five-minute averages form the basis for all subsequent data processing. The status of some 40 check points is written on the tape along with the packet of air quality and meteorological data to aid in editing of the data. Trailer data entries for a basic five-minute data set are given on Table 2-12. Met. tower data entries for a five-minute data set are given on Table 2-13. Nomenclature is given on Table 2-14.

A.1.1.5 Reporting Frequency and Format

Monthly, quarterly, and annual reports have been provided which summarize the air quality and meteorology at Tract C-b.

Monthly reports included the following data summaries:

(i) Downtime hours at each site

(ii) Daily averages for the month

(iii) Maximum five-minute averages and time of occurrence

(iv) The five maximum independent sliding* averages

(v) Functional dependence of air quality parameters upon wind direction

(vi) Diurnal variation of air quality and meteorological parameters

(viii) Stability wind roses

(ix) Direction-only wind roses

(x) Descriptive meteorological summaries

Additionally, quarterly reports included:

(a) Operating time analyses

(b) Quarterly air quality summary of concentration levels

(c) Quarterly particulate concentration summary

(d) Daily concentration summaries

*Time is incremented or "slid" by five-minutes and the average in question is computed and compared with the previous average; the maximum is saved.

A.1.2 Quality Assurance

A.1.2.1 Calibration and Operation of Air Quality Instrumentation

All continuous air quality analyzers are automatically calibrated by the minicomputer every day using a zero and single point span. The calibration system is a Meloy Model RAD-1 installed in each trailer instrument rack in which the calibration flows are controlled by a pressure regulator and temperature-balanced capillaries. All calibration gases are referenced to National Bureau of Standards materials.

Every six months multipoint calibrations are performed by an independent instrument engineer using a different calibration system. On a monthly basis, the linearizers in the SO_2 and H_2S analyzers are reset electronically, and the converter in the nitrogen oxides analyzer is checked. Charcoal scrubbers and filters are replaced quarterly.

At least two independent audit checks are performed annually on each station. The stations are attended daily by a trained operator.

A.1.2.2 Calibration and Operation of Meteorological Instrumentation

Field calibrations and preventative maintenance by meteorologists and meteorological technicians insure that the meteorological instrumentation is operating within the specifications of the manufacturer. These calibrations and maintenance checks consist of mechanical and electronic tests on the instruments, in addition to extensive tests on the electronics of the instruments (translators) as well as on the data acquisition system all according to detailed procedures. In the event that an instrument malfunction which cannot be repaired in the field is discovered during the calibration process, a replacement sensor is supplied from an inventory of spare meteorological instruments and instrument parts which is stored in the trailers.

During tower calibration the meteorologist inspects all hard-copy very closely to determine any possible instrumentation problems. Extensive cross-checks are conducted on relative humidities, temperatures, vertical temperature differences, wind speeds, and wind directions at all tower levels to identify all meteorological inconsistencies. Special attention is given to temperature differences and the alignment of the wind direction sensors.

The analysis, review, and quality assurance of the meteorological data are accomplished by a four-step procedure. First, all

applicable meteorological data for the National Weather Service (NWS) station (Grand Junction, Colorado) are recorded in a WBAN-10 format (the standard National Weather Service format). During the second phase of the procedure, the meteorological monitoring data are reduced to hourly averages (from five-minute averages) to facilitate the review. These hourly averages are affixed with parameter variability symbols to aid in the detection of erroneous data points. The third step in the quality assurance reviewing process consists of a complete hour-by-hour inspection of the monitored meteorological data using the WBAN-10 data and meteorological data from the other trailers in the monitoring network (when terrain effects are not extreme) for comparison purposes. The fourth and final step of the procedure consists of the correction and/or deletion of the incorrect meteorological data and the construction of the permanent data base (PDB) from the meteorological data which has been approved. The monthly reports are generated using this PDB.

An independent quality assurance technique is to provide reliability increases through redundancy. Wind speed and direction redundancies exist at three levels on the tower (30', 100', 200') via the standard vane and anemometers and the bivanes.

A.1.2.3 Trailer Design

As many quality assurance features as are feasible are designed into each station. Temperature is controlled within $\pm 3^0$F and is measured and recorded along with the air quality data, as is line voltage. A System Status Panel provides a visual indication of problems to the operator (e.g., excessive zero or span drift after each calibration) and a permanent record on the magnetic tape. Five monitoring stations were installed instead of the required four to assure adequate representation of the air quality at Tract C-b even during equipment failures. The results of each autocalibration are printed out daily for inspection by the operator. Numerous error flags are printed out on the hard copy to alert the operator to trouble (e.g., cassette not writing, NO_x < NO, THC < CH_4). The system automatically restarts following power failures and has a four-hour battery-back-up system. A battery powered clock assures that the correct time is associated with all air quality data.

A.1.2.4 Data Flow and Processing

Two redundant cassette tapes, one roll of hard copy, a daily operator checklist, and a logbook comprise the information collected at each station. One tape is mailed to the central data processing center, and one is retained on-site for use in case the

first tape is lost. The hard copy and daily checklist are mailed to the processing center separately from the magnetic tape. A copy of the logbook for the period of interest also is mailed separately.

Each item is logged in at the processing center. The cassette tapes (five-minute averages) are read into the data base, and hourly averages for the entire month are produced, along with error codes and flags. The autocalibration results for the entire month are printed out separately. The data base is edited using the checklists, logbook, error codes, and autocalibration results. Based on the editing, the proper five-minute values are entered into the permanent data base. The reports are produced using this data base.

Maximum errors in recording and processing a single data sample are conveniently summarized on Table A-1.

Operating efficiency requirements in the lease stipulations were addressed in Section 2-1 requiring 90 percent efficiency on the air quality parameters and 95 percent on the tower meteorology over the lease year. The numerical requirement was deleted in June of 1976.

Table A-1

MAXIMUM ERRORS IN RECORDING A SINGLE SAMPLE

CHANNEL	INSTRUMENT ACCURACY	DATA PROCESSING ERROR*
NO_x	± 5 ppb	± .62
NO	± 5 ppb	± .62
SO_2	± 10 ppb	± .74
H_2S	± 10 ppb	± .74
THC	± 50 ppb	± 1.72
CH_4	± 50 ppb	± 1.72
CO	± 50 ppb	± 1.72
O_3	± 5 ppb	± .62
Wind Speed (met. tower)	± 1.0 mph	± .52 mph
(reg. tower)**	± .5 mph	± .52 mph
Wind Direction (met. tower)	± 5.4 deg	± .63 deg
(reg. tower)	± 5.4 deg	± .63 deg
Temperature (met. tower)	± .45 F^0	± .54 F^0
(reg. tower)	± .3 F^0	± .54 F^0
Relative Humidity (met. tower)	± 3.0 percent	± .52 percent
(reg. tower)	± 5.0 percent	± .52 percent
Change in Temperature	± .18 F^0	± .006 F^0
Barometric Pressure	± .5 millibars	± .52 millibars

*Error due to rounding to integers for one five-minute average or sample
**Regular towers are attached to each trailer

A.2 EG&G Upper Air Studies

The purpose of these studies was to investigate the temperature and wind structure of the atmosphere over the Tract as a function of time of day as well as season. These data helped determine mixing layer depths and inversion frequencies of occurrence.

A.2.1 Methodology

A.2.1.1 Data Sampling and Reduction Techniques

A.2.1.1.1 Data Collection

The revised conditions of approval required 15 days of upper air wind and temperature data each season. To determine the diurnal variation in the wind and temperature structure, four aircraft temperature soundings and simultaneous pilot balloon soundings were attempted each day. Because inclement weather could force cancellation of aircraft flights and limit pilot balloon tracking, a successful day was defined as the performance of a minimum of two temperature soundings, one of which was flown into the Piceance Valley. The four soundings (both aircraft and pilot balloon) were nominally flown at 0500, 0800, 1100, and 1700 hours Mountain Standard Time (MST). The 0500 and 1700 hours MST soundings were performed simultaneously with National Weather Service Rawinsonde soundings made at Walker Field in Grand Junction, Colorado. This was done to provide an indication of the correlation between Tract C-b and Grand Junction and an estimate of the representativeness or applicability of Grand Junction data to conditions occurring over the Tract. The primary purpose of the 0800- and 1100-hour MST soundings was to investigate the formation and breakup of surface-based inversions.

The vertical temperature structures from the surface to 13,000 ft. above Mean Sea Level (MSL) were determined with a sensitive shielded thermistor mounted on the wing strut of a light aircraft. Weather permitting, soundings were made to within 100 feet of the surface during the daylight hours; during night flights, 500-foot safety margins were observed. During the 0500-, 0800-, and 1100-hour MST soundings over Tract C-b, the flight path called for a slow, gradual ascent from approximately 50 feet above the surface of the Piceance Creek in a general direction toward the Tract and the 200-foot meteorological tower to an actual top-of-tower fly-by. This fly-by at 7200 feet above MSL was performed to check the aircraft altimeter setting. The aircraft then began its normal ascent

to 13,000 feet above MSL at a rate of approximately 10 feet per second in a one-kilometer diameter spiral centered over the meteorological tower. On a normal flight path, the temperature measurements made at the level of the base of the Tract C-b tower were, therefore, made about one kilometer to the north. Because of this data below 7200 feet above MSL cannot accurately be termed "vertical" temperature soundings, even though the 10-feet per second ascent rate was maintained along the horizontal portion of the flight path. Altitude markings were made on the temperature chart in real time at 100-foot increments by an observer. While the pilot attempted to maintain a constant rate of ascent, this was not always possible primarily because of turbulence. For this reason, temperature and altitude readings were taken from the charts only at points marked with a distinct altitude. No interpolations between markings were used.

To investigate the existence of measurable horizontal temperature gradients associated with the presence of an inversion, a number of flights were flown at constant altitudes through the Piceance Creek valley. These flights, which were only flown in the presence of inversions, started over the confluence of Ryan Gulch and the Piceance Creek valley and terminated just over the Redd Ranch. They were flown at constant altitudes of either 100 or 200 feet above the valley floor (6300 feet above MSL) depending upon safety considerations.

The vertical wind structures from the surface of the Tract to 13,000 feet above MSL were also determined four times per day in conjunction with the aircraft temperature soundings by tracking 30-gram pilot balloons with a single theodolite. The theodolite was aligned to magnetic north using an internal compass, and then corrected to true north by rotating the platform 15 degrees counterclockwise. The pilot balloons were carefully "weighed off" by using a standard National Weather Service inflation kit for 30-gram balloons inside an enclosed area to avoid the influence of wind. The balloons were released from the SG-10 well site about 800 meters north-northeast of the 200-foot meteorological tower. During nighttime soundings, small water-activated batteries connected to a tungsten filament lamp were attached to the balloon before it was weighed off to allow optical tracking. At 30-second intervals (indicated by an electronic timer), azimuth and elevation were vocally recorded to within 0.1 degrees, although interpolations were attempted to within 0.02 degrees.

The principle of pilot balloon observations is based on the assumption that the mean wind velocity in a particular layer is represented by the movement of the free balloon in that layer. Therefore the wind speed and direction were calculated from sequential horizontal coordinates of the balloon (under the assumption of constant ascent rate) and the resultant data were interpreted to be indicative of the motion of the air at the mean height of the layer bounded by the sequential observations.

The seasonal studies were performed during the periods as follows:

Fall: 1 October through 15 October 1974

Winter: 20 January through 9 February 1975

Spring: 14 April through 1 May 1975

Summer: 12 July through 26 July 1975

A.2.1.1.2 Data Reduction of Pibal Measurements

The balloon was inflated to yield a "nominal" ascent rate of 600 ft./min., an assumption utilized in this technique.

The height H in ft. at time t_i in min. is given by

$$H_i = 600\ t_i$$

Horizontal distance, D, in ft. to the balloon is given by

$$D_i = H_i \cot \alpha_i$$

where α_i is the measured elevation angle at t_i. Then

$$X_i = D_i \sin \beta_i = \text{displacement of balloon X axis (ft.)}$$

$$Y_i = D_i \cos \beta_i = \text{displacement along Y axis (ft.)}$$

where β_i is the measured azimuth angle at t_i.

The mean wind velocity components, during the time increment $(t_{i+1} - t_i)$ and through the height increment $(H_{i+1} - H_i)$ are

$$\frac{X_{i+1} - X_i}{88\ (t_{i+1} - t_i)} = u_j \qquad \text{(MPH)}$$

$$\frac{Y_{i+1} - Y_i}{88\ (t_{i+1} - t_i)} = v_j \qquad \text{(MPH)}$$

The subscript j is used to indicate that the velocity components are assigned to a time $t_j = t_i + 0.5$ and a height $H_j = H_i + 0.5$.

The total wind speed (V_j) at H_j is

$$V_j = + \sqrt{u_j^2 + v_j^2} \qquad \text{(MPH)}$$

The wind heading (direction toward which air is moving) is

$$\gamma_j = \tan^{-1} \frac{u_j}{v_j} + \gamma_o$$

If $v_j > 0,\ u_j > 0;\ \gamma_o = 0^o$

$v_j < 0,\ u_j > 0;\ \gamma_o = 180^o$

$v_j < 0,\ u_j < 0;\ \gamma_o = 180^o$

$v_j > 0,\ u_j < 0;\ \gamma_o = 360^o$

Time into the flight and elevation and azimuth angles were recorded vocally on magnetic tape and later transcribed to paper. From these H_i, X_i, Y_i, H_j, V_j, and γ_j were calculated and recorded. When an angle was missing, presumably because the observer was unable to track the balloon or was unable to transcribe the data from magnetic tape, a 999.00 was entered.

A.2.1.1.3 Data Reporting

A report detailing the actual temperature and wind profiles for each sounding along with data quality checks was prepared within 30 days of the end of each quarterly study. The temperature profiles were plotted as a function of height using a computer program developed by EG&G under their quality assurance program. Wind speed and direction were calculated at 300-foot intervals from the pilot balloon data using another program developed by EG&G which also plotted the wind direction profile as a function of height and the actual balloon trajectories in the form of hodographs for each sounding. In addition, an annual summary report condensing the results of all four studies was prepared at the end of the program.

A.2.2 Quality Assurance

A.2.2.1 Calibration Techniques and Frequency

Temperatures were recorded with an EG&G Model 702 Portable Temperature Recorder which is designed to achieve high resolution temperature recording from a moving vehicle. The unit is capable of measuring temperatures from -30^0C to $+32^0$C over six ranges with an absolute accuracy of more than $\pm 0.2^0$C, although for the upper air studies described, the unit was calibrated to within $\pm 0.1^0$C. The recorder resolution is $\pm 0.1^0$C and is operated at a speed of one inch per minute. The time response of the thermistor sensor is less than two seconds in stagnant air.

The entire unit was calibrated immediately before each seasonal upper air study by placing the thermistor sensor and radiation shield within an environmental chamber with forced circulation along with a platinum wire temperature probe traceable to the National Bureau of Standards. The temperature recorder was then adjusted for each of its six ranges to correspond with the platinum wire standard. This 12 stage multi-point calibration was documented and recorded according to the EG&G quality assurance program. Drift between quarterly calibrations never exceeded $\pm 0.2^0$C for all ranges.

The altimeter reading was checked prior to, during and after every sounding. The tower-top fly-by check indicated an elevation of 7200±50 feet above MSL for all soundings and was typically within 20 feet of the actual surveyed elevation of 7180 feet above MSL level.

Several factors influence the accuracy of the calculations from the pilot balloon observations. The errors which may occur are a result of platform orientation errors, errors arising from not having the theodolite crosshairs centered on the balloon at the time of reading, errors in the timing interval, and errors caused by a non-constant rate of ascent. The first three of these types of errors typically cause no more than a one meter per second wind speed and 3^0 wind direction error within the first 2000 feet above the surface. The errors grow rapidly above this height.

The National Weather Service inflation kit used to weigh off the 30-gram pilot balloons requires no calibration. Because the theodolite drive mechanisms operate purely mechanically, the only adjustment required to the device is alignment of the crosshairs between the two optical ranges. This adjustment was checked periodically throughout each study. The crosshair alignment difference between the two ranges never exceeded ±0.2 degrees. Day-to-day alignment repeatability of the theodolite platform was within ±1.5 degrees from true north in a horizontal plane and within ±1 degree in a vertical plane.

The largest source of error in the single theodolite procedure used here is caused by assuming a uniform ascent rate. It is not unusual for a small balloon to descend instead of ascend during such a flight. With unstable conditions the balloon may undergo repeated up and down motions as it passes through convective cells. There is no way to detect this and correct for it when the only instrument is a single theodolite. The difficulty can be partially overcome by smoothing both elevation and azimuth angles before calculating wind velocities. This has the effect of averaging the wind velocities over greater time and height increments, but there is no assurance for any particular sounding that these averaged values do not contain errors. The error is not likely to be systematic, however, and averages over a large number of flights are useful.

Under stable conditions the error is systematic. The balloon slows its ascent as it rises through an inversion. In strong deep inversions such as those experienced at the C-b Tract at night, a balloon may even cease to rise altogether for a time. This has two serious effects: it yields wind data which are much too strong, and it misinterprets the altitude assigned to the data. Thus weak winds at the level at which the balloon stalls in its ascent appear to be strong winds at higher altitudes. Again there is no way from the single theodolite to correct for these errors. Furthermore, since the errors are systematic, averages over large numbers of flights taken under these circumstances may be misleading.

A.2.2.2 Equipment Reliability

No problems were encountered with the equipment during these tests. Inclement weather, on occasion, required more flight attempts than 15 days per quarter to achieve 15 successful days per quarter; attempts vs. successes have been previously documented in the quarterly reports.

A.3 Marlatt and Associates Acoustic Sounders

A.3.1 Methodology

A.3.1.1 Principles

Acoustic sounders have alternatively been called acoustic radars, sodar (for sound detection and ranging), and acdar (for acoustic detection and ranging). Acoustic energy that is propogated through the atmosphere is scattered by turbulent fluctuations in temperature and wind velocity (Tombach, MacCready, and Baboolal (1973). Clark and Bendun (1974) sum up the principles of acoustic sounding as follows:

> "Acoustic sounding involves transmission of sound waves, a scattering of these from irregularities of this atmospheric acoustic refractive index, and reception of the echoes at a ground based station. Theory has shown that when the transmitter and receiver are coincident (monostatic system), the backscattered energy is dominantly a function of the spatial variations of temperature. If the transmitter and receiver are separated and the sound follows an oblique path (bistatic system), the acoustic scattering is also a function of the spatial variability of the wind fluctuations. . . "

Wycoff, Beran and Hall (1973), in slightly different form, sum it up this way:

> "Sound energy that is directly back-scattered (180^0 from the direction of the incident wave) is solely the result of temperature fluctuations in the scattering volume. Acoustic energy scattered in all other directions (except at 90^0 to the incident beam, where no scattering occurs) is the result of the combined effect of wind and temperature fluctuations.
>
> This angular dependence of the scattering mechanism is of paramount importance to the operation of a sounder. For a monostatic configuration (co-located transmitter and receiver; scattering angle of 180^0), one observes echoes that depict the temperature structure constant, C_T, in the atmosphere. With neutral static stability, C_T

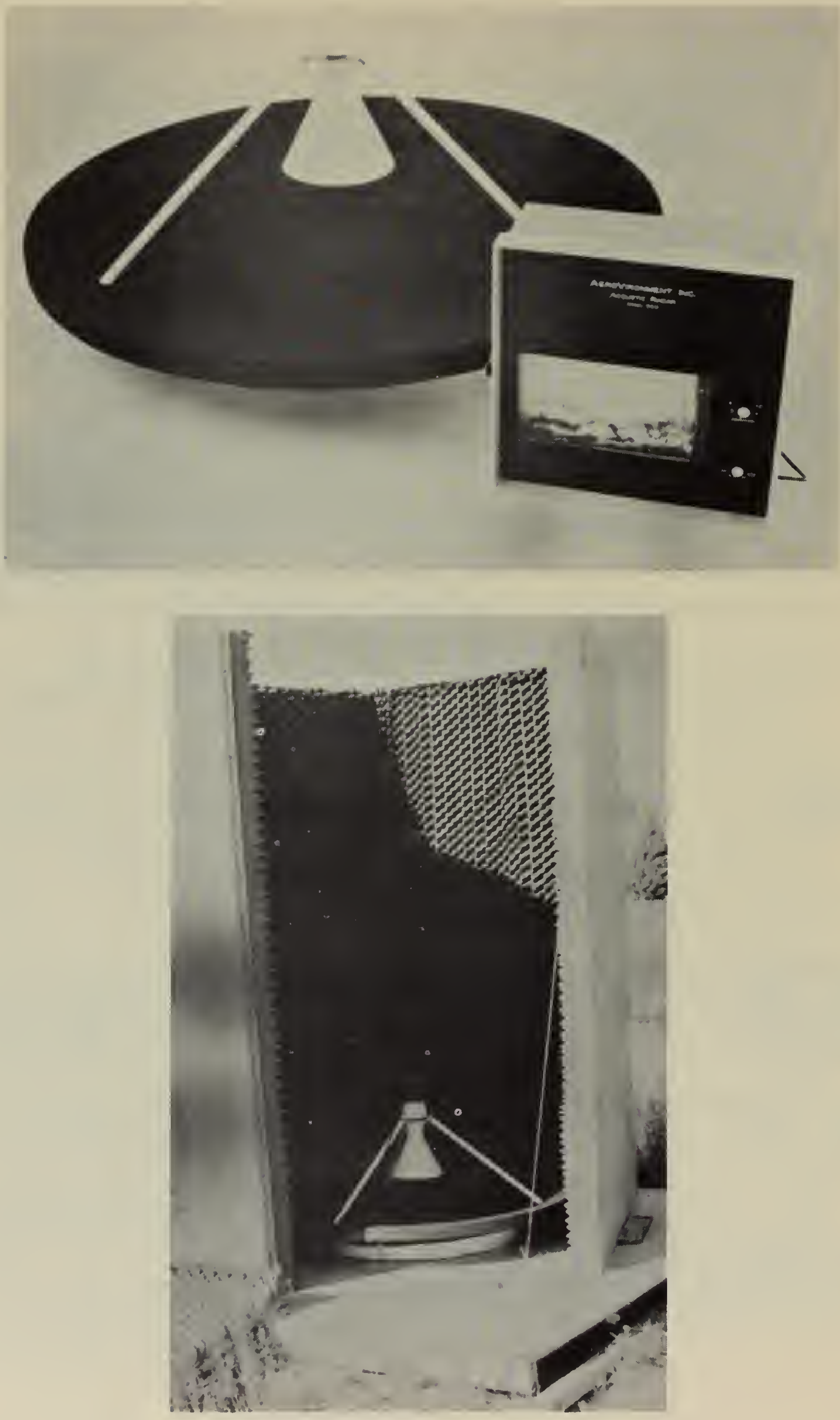
values are very low, and the scattered energy will be undetected. If a facsimile recorder is used to display the echo intensity, where each sweep of the recorder corresponds to the time required for a single sound pulse to traverse the region of interest, the record will be white when no echoes are received. As the lapse rate changes from adiabatic (either more stable or less stable), any mechanical turbulence in the air will create small-scale temperature eddies capable of backscattering some of the incident sound, and the facsimile record will be darkened in proportion to the strength of the turbulence. The monostatic sounder, therefore, gives an indication of each change in lapse rate or dynamic stability along the path of a transmitted sound pulse, producing a record with a striking amount of contrast and showing considerable detail related to the thermal structure. . . "

A.3.1.2 Sampling Techniques, Frequency, and Format

The specific acoustic sounders at Tract C-b are co-located with the air-quality trailers at Station 023 (at the meteorological tower), initially at Station 021 (at Rock School in Piceance Creek valley) and later at Station 020 at Redd Ranch). The specific instrument is the Aerovironment, Model 300, Acoustic Radar whose specifications are given on Table A-2. The instrument and its shelter are shown on Figure A-2; for this instrument the acoustic energy is generated by the white transducer above the circular antenna and transmitted downward through the cone and reflected into the atmosphere in the form of a narrow beam by the parabaloidal antenna dish. The path of acoustic energy is reversed for receiving the echoes of scattered sound with the transmitter now acting as a microphone. Continuous data have been obtained, except during periods of malfunction, from strip-chart recorders. The recorder principles-of-operation are as follows: The recorder contains a stylus which is drawn across special paper and which makes a mark whose intensity is related to the magnitude of the received signal. The stylus starts at the bottom of the paper when the pulse is transmitted and reaches the top when echoes from the desired full-scale range have been received. Height of the trace indicates round trip travel time of an acoustic wave from the antenna to the scattering region. Full scale on the trace is equivalent to a height of 1000 meters. The strip chart is not only scaled vertically with height but also horizontally with time. The normal operating time for each strip chart was one month.

Table A-2 SPECIFICATIONS OF
AEROVIRONMENT MODEL 300 ACOUSTIC RADAR

Transmitted Pulse:	Frequency -- 1600 Hz Duration -- selectable 50, 100, or 200 ms Power Input -- 35W Repetition Rate -- 1 per 7 seconds (500 m scale) -- 1 per 14 seconds (1km scale)
Receiver:	Gain -- 10^8 Gain Compensation -- proportional to time of echo return, with additional adjustment possible for short ranges Bandwidth -- less than 20, 40, and 80 Hz (between -- 3 dB points, 72 dB/octave cutoff) for 200, 100, and 50 ms pulses respectively, automatically switched when pulse length is changed Range -- Selectable 1 km or 500 m full scale Minimum 10 m due to 60 ms receiver dead time after pulse transmission Resolution -- 10 m
Recorder:	Writing Technique -- electric on conducting chart paper Chart size -- 6" (15.2 cm) wide by 72' (22 m) Chart speed -- 1.25" (31.8 mm)/hour Chart duration -- 28 days
Sound Level (with Model 301 Acoustic Enclosure):	Transmitted horizontally -- <60 dBA at 10 m Maximum Ambient for Operation -- approximately 68 dBA for 1 km scale, 74 dBA for 500 m scale
Size & Weight:	Electronics and Recorder -- 17" W x 17" H x 6" D, 45 lbs. (43 cm W x 43 cm H x 15 cm D, 18 kg) Antenna and Transducer -- 52" dia x 36" H, 58 lbs. (133 cm dia x 80 cm H, 23 kg)
Power Input:	115V, 60 Hz, 50W



THE AEROVIRONMENT MODEL 300 ACOUSTIC RADAR
AND A CUTAWAY OF ITS ENCLOSURE

FIGURE A-2

A.3.1.3 Reporting Frequency and, Format

Data were digitized by first indicating the existence of stable layering with markings enveloping the regions of return. The time variations which occurred in the strip-chart speed were adjusted in order to match the annotated starting, ending, and interim time checks entered on the charts at the field locations. The raw data were developed by recording the height of the stable layers at 30-minute intervals and the raw data were then reduced and tabulated on a monthly basis to provide information regarding the average heights, durations, and onset and dissipation times. The monthly data were then accumulated and reported in the quarterly summaries. Raw data on punched cards and reduced data in printed form were submitted with the quarterly reports.

A.3.2 Quality Assurance

A.3.2.1 Calibration Checks

There are only two major factors affecting the calibration of the acoustic echo sounding units used. The first is the ambient air temperature which alters the speed of sound and therefore the speed of an impulse as it is transmitted and returned through the atmosphere. The manufacturer suggests that a sound-speed correction of +5 percent be applied at temperatures above 34^{0}C (93^{0}F) or a -5 percent at temperatures below -26^{0}C (-15^{0}F). Vertical resolution of the acoustic echo sounder is estimated to be 20 meters (66 feet), well within the resolution requirements for defining the mixing depth or height of stable layering. For calibration checks, the operation of the acoustic echo sounder was correlated with both tethersonde and aircraft measurements as discussed elsewhere in this report.

The second major factor affecting the instrument accuracy is the speed variation of the synchronous motors which drive the stylus carrying-belt and the strip chart. These motors proved to be susceptible to fluctuations in line voltage, but the frequent time checks after January 1976 alleviated most of this difficulty when the motors were not operating at the proper speed. The marginal torque of these motors created most of the problems and missing data segments. Prior to January 1976 less frequent time checks were made. By comparison of the sounder with aircraft overflys - indicating a trace on the sounder record, time increment differences were estimated. The range of time increment was -37 to +29 minutes; mean difference was -8 minutes.

Other limitations on the equipment were 1) snow accumulations on the exposed radar dish caused equipment malfunction,

2) inversions could be obtained up to the height limitations of the sounder record - 1000 meters (3280 feet), and 3) sounder signatures were often "fuzzy" and difficult to interpret.

It is to be noted that the manufacturer has no published recommended frequency of field calibrations.

A.3.2.2 Equipment Reliability

Table A-3 is a summary of the instrument reliability for Site 023 which had the most complete and longest record for the experiment. Reliability has been calculated as the installed instrument "up" time divided by the operational span all multiplied by 100 percent. The table shows that measurements were made continuously 69 percent of the time between December 7, 1974 and November 2, 1976. Table A-4 shows the reliability of the instrument located at Site 021. At this location, measurements were accomplished 48 percent of the time between June 1, 1975 and June 13, 1976. Table A-5 is the summary of instrument reliability at Site 020. The continuous measurements at this site were made 37 percent of the time between June 13 and October 16, 1976.

Table A-3

ACOUSTIC SOUNDER INSTRUMENT RELIABILITY AT STATION 023

Month	Year	No. of Days Measurements	No. of Days Available
December	1974	25	25
January	1975	30	31
February	1975	28	28
March	1975	27	31
April	1975	21	30
May	1975	29	31
June	1975	0	30
July	1975	15	31
August	1975	11	31
September	1975	29	30
October	1975	20	31
November	1975	22	30
December	1975	30	31
January	1976	24	31
February	1976	28	29
March	1976	31	31
April	1976	5	30
May	1976	22	31
June	1976	18	30
July	1976	0	31
August	1976	21	31
September	1976	20	30
October	1976	24	31
November	1976	2	2
	TOTALS	482	697
	PERCENT	69	

Table A-4

ACOUSTIC SOUNDER INSTRUMENT RELIABILITY AT STATION 021

Month	Year	No. of Days Measurements	No. of Days Available
June	1975	0	30
July	1975	14	31
August	1975	5	31
September	1975	0	30
October	1975	0	31
November	1975	23	30
December	1975	10	31
January	1976	18	31
February	1976	24	29
March	1976	30	31
April	1976	30	30
May	1976	19	31
June	1976	10	13
	TOTALS	183	379
	PERCENT	48	

Table A-5

ACOUSTIC ECHO SOUNDER INSTRUMENT RELIABILITY AT STATION 020

Month	Year	No. of Days Measurements	No. of Days Available
June	1976	13	16
July	1976	14	31
August	1976	2	31
September	1976	1	30
October	1976	16	16
	TOTALS	46	124
	PERCENT	37	

A.4 Ambient Analysis Tethersonde Study

A.4.1 Methodology

A.4.1.1 Data Sampling and Reduction Technique

A series of soundings was made by a small tethered balloon sounding system on the C-b Oil Shale Tract in the Piceance Creek basin of Colorado during the period 15 June through 7 July 1976. The soundings were made alternately at two sites, Stations 020 and 023 at two-hour intervals six times a day. The times for the flights were selected to show conditions during the stable, early morning hours, to provide night-to-day transition data, and to yield information about mid-day convective activity. A total of 59 flights were made.

The purpose of the program was to obtain meteorological data in the stratum from the surface up through the level to which a pollutant plume from a plant on the C-b Tract might rise - tentatively assumed to be 600 ft. above the surface at Station 023. This station is 630 ft. above Station 020. A 200-ft. meteorological tower is located at Station 023. The flights from Station 020 were halted at tower height (i.e., tethering rate was temporarily stopped, then restarted) so that comparison of measurements between the two stations could be made. Tethering rate from both stations was also stopped and restarted at the assumed plume height. Comparisons of data between the tethersonde and the tower and two acoustic sounders located at the two stations were also made.

A.4.1.1.1 Data Collection

The tethersonde system is shown on Figure A-3. It consists of a sensor subsystem, a telemetry subsystem, a recorder, an aerodynamically-shaped balloon to carry the sensor subsystem aloft, and a winch to control the balloon. The sensor subsystem contains sensors for barometric pressure, temperature, wet-bulb temperature, wind speed, and a magnetic compass. The compass is maintained in a fixed relationship with the balloon and the orientation of the balloon is taken as the wind direction.

The telemetry transmitter and some sensor signalling conditioning circuitry are located in the airborne package on which

TETHERSONDE SYSTEM

FIGURE A-3

the sensors are mounted. It is suspended below the balloon at a sufficient distance (2m) to avoid influence from the balloon. Also the two lines in the suspension are held apart by two spacers to help make the suspension torsionally rigid and so assure that the balloon and sensor package maintain the same orientation.

The telemetry receiver and a discriminator are located in the ground station. The incoming signal is received by the receiver and changed from a frequency to a voltage by the discriminator. It is then sent to the recorder. The telemetry system is time-multiplexed. Figure A-4 is a typical section of the strip chart record (Flight 46).

The tethersonde may be used to make vertical soundings by running it up and down at whatever rate is appropriate for the purpose to be served, or it may be flown at approximately a constant level to obtain data at that level. In the work on the C-b Tract it was used in both of these modes.

A.4.1.1.2 Data Reduction

The tethersonde data consist of the graphical record (strip chart) produced by the tethersonde and tabulated data derived from the graphs. The tethersonde, as it was used in this work, was set to produce a data frame once each minute. During each, temperature, wet-bulb temperature, and wind speed are sampled twice; pressure and wind direction are each sampled once. Also during each frame a full-scale reference and nine zero references are produced. All values are scaled linearly between the zero and full-scale references. Hence, although drift and span changes are normally small, the data can readily be corrected for them.

In evaluating the tethersonde record, it is common practice to connect all chart values of each variable with a continuous smooth curve. Readings taken along such a curve provide satisfactory interpolations for most data. Wind speed varies more rapidly than any of the other meteorological variables measured. Wind direction is also quite changeable. Therefore, interpolated values of these are more questionable than for the other variables measured. The tethersonde provides more frequent and more precise information, however, than any other method of making soundings currently in use. The data for this study were reduced in such a manner that linear interpolations between tabulated values will produce essentially the same data as the chart recording.

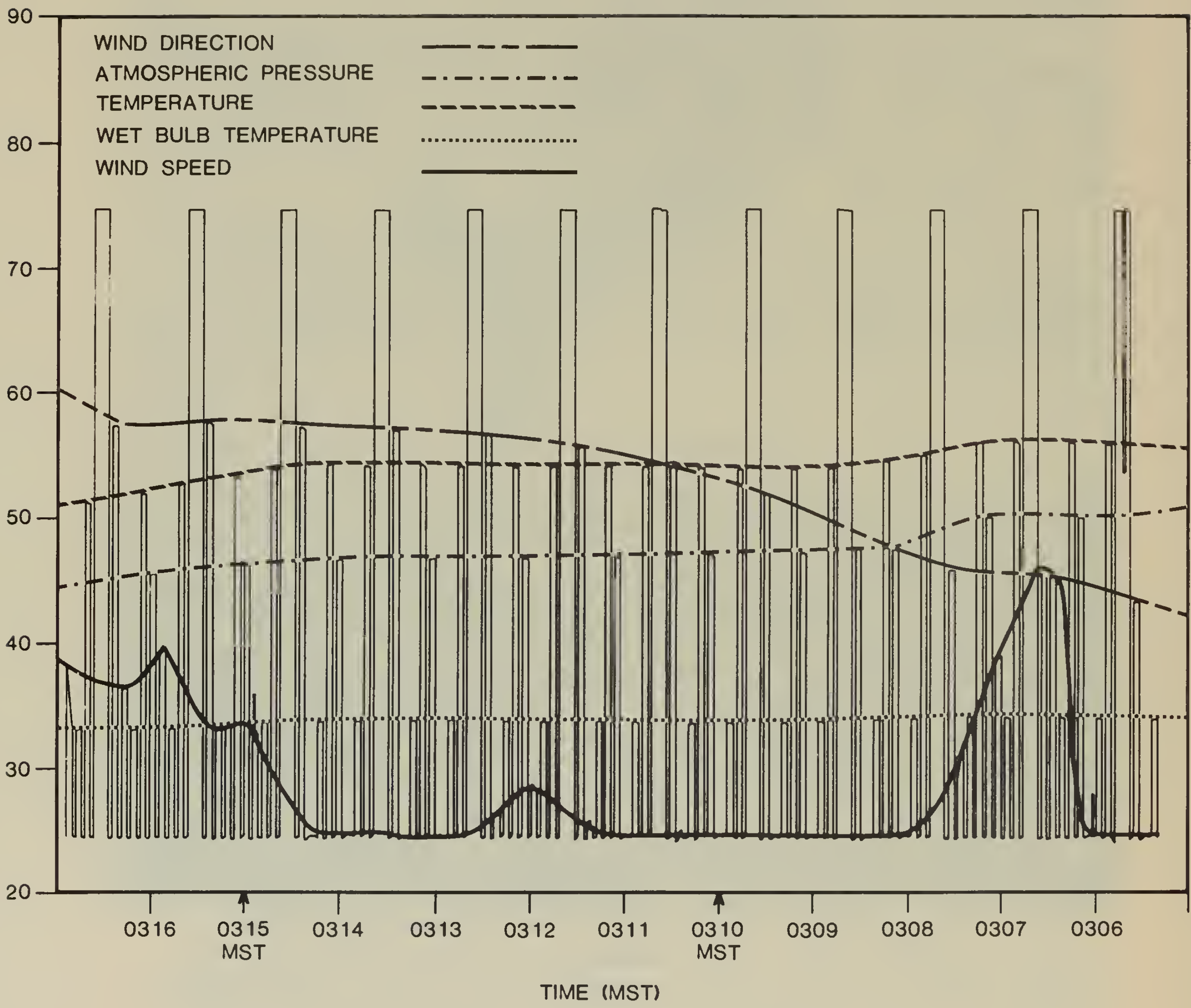


FIGURE A-4

TYPICAL SECTION OF TETHERSONDE STRIP CHART RECORD
(FLIGHT 46 LAUNCHED AT STATION 023 AT 0335 MST, 27 JUNE 1976)

A.4.1.1.3 Calculation of Standard Deviations

In addition to the above basic data, derived data on horizontal wind speed standard deviation (σ_u) and horizontal wind direction standard deviation (σ_θ) were obtained on both the ascending and descending portions of the flight. The reference altitude selected was 600 ft. above the surface at Station 023 and 1300 ft. above the surface at Station 020 (since Station 023 is approximately 700 ft. above Station 020). A five-minute sampling time span (±2.5 minutes) about this altitude was selected, yielding five one-minute samples each for ascent and descent for wind direction and 10 for speed. Standard deviations were obtained from range with the conversion being a function of sample size (σ_θ = 0.430 x range; σ_u = 0.325 x range). In addition, an average standard deviation ($\sigma_{u_p}, \sigma_{\theta_p}$) over the ascent and descent was obtained by pooling the variances according to the following equation (Dixon and Massey 1969):

$$\sigma_{\theta_p} = \left(\frac{(n_1-1)\sigma_{\theta_1}^2 + (n_2-1)\sigma_{\theta_2}^2 + \ldots\ldots\ldots (n_k-1)\sigma_{\theta_k}^2}{n_1+n_2+ \ldots\ldots\ldots n_k-k} \right)^{\frac{1}{2}}$$

where

n_1 = number of ascent samples = 5 for direction, 10 for speed

n_2 = number of descent samples = 5 for direction, 10 for speed

k = 2 (1 (ascent) & 1 (descent))

Hence, for this application

$$\sigma_{\theta_p} = \left(\frac{4\sigma_{\theta_A}^2 + 4\sigma_{\theta_D}^2}{8} \right)^{\frac{1}{2}} = \left(\frac{\sigma_{\theta_A}^2 + \sigma_{\theta_D}^2}{2} \right)^{\frac{1}{2}}$$

with the same resultant equation for σ_{u_p}.

A.4.2 Quality Assurance

A.4.2.1 Calibration and Precision

Tethersonde sensor specifications are presented on Table A-6.

The sensors used for wet and dry bulb temperatures are devices consisting of precise thermistors and resistors which produce a resistance that is linear with temperature.

The tethersonde has two such matched thermistors 2 cm apart along the axis of a specially designed, aspirated tube that is shielded from radiation. One of the thermistors is covered by a wick which can be kept moist by water from a small reservoir. This psychrometer has been tested in a chamber in which both temperature and relative humidity could be closely controlled. The wet and dry bulb temperature specifications stated (Table A-6) can be readily verified in a controlled chamber. The time constant for the dry thermistor is much less than 10 s in the aspirated tube. The tethersonde-type dry and wet bulb temperatures have been checked against dry and wet bulb temperatures measured by an Assmann psychrometer. No significant difference has been found.

The pressure sensor is a small aneroid cell on which a thermistor is mounted. The thermistor provides input to the pressure measuring circuitry to enable it to compensate for variations of aneroid temperature. The output from the pressure subsystem is nearly linear with pressure from 700 to 1050 mb. Through a range of 100 mb the linear approximation is quite good, according to the manufacturer. As a check on pressure, the length of the tether line has been measured on occasions when the balloon was nearly directly overhead. Heights based on atmospheric pressure and temperature data have agreed well with line length on those occasions.

Although the pressure sensor could be used as an absolute sensor, it is not used that way in the tethersonde. Therefore, it is necessary to have a reference pressure at the launch point to be able to measure absolute pressure at levels above the surface. If tethersonde data are referred to an accurate standard at the beginning of a flight, the manufacturer believes that measured pressures will be accurate to within one millibar throughout the flight.

As part of the calibration the wind-speed sensor manufacturer determines starting speed. It usually falls below 0.8 m/s. Clearly if anemometer cups or bearings become damaged, the lower limit of the speed range can be expected to be higher than the value stated in the tethersonde specifications.

Table A-6

TETHERSONDE SENSOR SPECIFICATIONS

Dry and Wet Bulb Temperature (aspirated).

- Range: -50°C to + 50°C
- Precision: ±0.5°C
- Resolution: 0.1°C
- Sensor: Bead thermistor

Differential Barometric Pressure:

- Range: 0 to 100 millibars
- Precision: ±1.0 millibars
- Resolution: 0.5 millibars
- Sensor: Aneroid Strain Gage

Wind Speed (horizontal):

- Range: 0.5 to 20 meters/second
- Precision: ±0.25 meters/second
- Resolution: 0.1 meters/second
- Sensor: Cup anemometer

Wind Direction:

- Range: 0 to 360°
- Precision: ±5°
- Resolution: 2°
- Sensor: Magnetic Compass

The orientation of the tethersonde is determined relative to the earth's magnetic field by means of a small magnetic compass. When orientation is to be sensed, a solenoid in the compass is activated. It locks the needle in place in contact with a potentiometer, which in turn provides a resistance value to the tethersonde.

The tethered balloon is assumed to be a satisfactory wind vane and the tethersonde is suspended so that it maintains a fixed orientation relative to the balloon. Thus the orientation of the tethersonde is assumed to be determined by the wind direction. Calibration on the ground is a simple matter. The tethersonde is oriented manually in a number of compass directions which are compared with the signal output. In this calibration procedure the manufacturer's specifications are easily met.

Over the past two years, wind direction accuracy has been checked in two ways. When it was flown near a 150 m tower, indicated direction at tower top level was compared with wind direction measured by a wind vane mounted near the top of the tower. The tower influence on the wind vane was not known completely, and the tower and tethersonde measurements were 100 to 200 m apart. The two measurements were essentially the same, nonetheless. To check internal consistency of the tethersonde system, the orientation of the balloon has been determined by observing its image in a circular, horizontal mirror that was graduated like a compass and oriented by magnetic compass. The results of observations and tethersonde output agreed to within $\pm 5^0$ in virtually every case. This technique can be used only when the balloon direction is relatively constant.

Precision of derived data, height and potential temperature, is obtained from the total differential of their respective governing equations. Assuming $\Delta P = 1$ mb and $\Delta T = 2^0$F, the estimated precision in height is 35 feet. In similar fashion, the estimated precision in potential temperature is 0.55^0K.

As was previously mentioned, the relationship of range to standard deviation (for normal distributions at least) is a function of sample size. Separate estimates were made of σ_θ and σ_u. Under the assumption that $\sigma_u \approx \sigma_v$, $\sigma_\theta X = \sigma_v T$ where $X = \overline{UT}$ and T = time, $\overline{U}$ = average speed, X = distance travelled downstream. The left and right-hand sides of this equation were separately computed. The mean ratio of the left to the right side over 59 flights is 1.229.

A.4.2.2 Equipment Reliability

The airborne sensor package which was taken to the C-b Tract initially was lost early in the program. The replacement package was a new one, and although it was calibrated before it left the factory, it had not been operated previously in the field. It developed some problems. The aspirator motor failed and had to be replaced. It was replaced as soon as a new motor could be received. Nonetheless, on Flights 13 through 16 the wet-bulb temperatures are bad and temperatures are doubtful. The pressure sensor on the package developed a lag which was observed on some flights and not on others. This could be partially corrected by checking it against known values at the beginning and end of each flight. It could also be checked by comparing ascent and descent temperatures, and by the consistency of computed potential temperatures. Even with these corrections and checks, pressure values on flight Nos. 47, 49, 54, and 55 may be in error at the top of the sounding by as much as 3 mb. This is approximately equal to an error of 100 ft. in height. The manufacturer claims a precision of ± 1 mb and, normally, relative errors can be held to that. Thus it is felt that errors on a few flights may be three times as large as should be expected. Even so, no other sounding system in existence can do better.

With these exceptions noted above, it is felt that the specifications stated previously were met by the system and in the data reduction process.

A.4.3 Data Presentation

A.4.3.1 Reporting Frequency

Data were recorded on a strip chart recorder. The charts were read after completion of the flights and data were reduced to show the most significant variables in the following three forms: all data from 59 flights were punched on cards; all were tabulated; selected data were plotted on graphs of various kinds.

A.4.3.2 Format

All data are reported in Quarterly Report #8 in the format depicted by Table A-7.

Derived data on standard deviations are presented in Appendix B of this volume.

Table A-7

TETHERSONDE DATA KEY

Symbol	Description
F	Flight number
S	Site number on C-b Tract
Y M D	Day of month Month Year - '76
P_o	Station pressure - mb
T1	Time - hours, minutes and tenths of minutes
P	Pressure difference - mb
T	Temperature - ^oF
T_w	Wet-bulb temperature - ^oF
R	Relative humidity - %
V	Wind speed - mph
D1	Wind direction - deg clockwise from north
H	Height above surface - ft
θ	Potential temperature referred to 1000 mb - K

A.5 Mechanical Weather Stations

A.5.1 Methodology

Continuous measurements of ambient air temperature, wind speed, and wind direction of three locations on or near the C-b Shale Oil Tract were made with Meteorological Research, Inc. Mechanical Weather Stations.

The Mechanical Weather Station shown in Figure A-5 is a self-contained, complete system, compact in overall size and weight with the ability to sense and simultaneously record three important climatological parameters. The functional objectives of the station are: easy transportation to all locations, uncomplicated field installations, prolonged periods of operation without inspection or attendance of any kind, no outside power sources required, and operational capability over the widest possible ranges which might be encountered in basic research by a data gathering system.

The rugged utility of the MWS is matched by the high sensitivity of each separate function. Accuracy of the Wind Direction, Speed, and Air Temperature measurements are ±2 percent of full scale. Good resolution of recorded data -- black marking on white moisture-resistant chart paper facilitates interpretation. Instrument specifications appear on Table A-8.

A.5.1.1 Sampling Techniques, Frequency, and Format

Wind Direction is sensed by a ball-bearing-mounted, balanced, single-blade, aluminum vane with nose damping. The precise reactions to winds of varying intensity and direction are explained in the quality assurance section.

The Wind Speed (run) is measured by a cup anemometer employing three 4-1/2" diameter conical aluminum cups. These cups are placed directly above the directional vane on the center shaft allowing the system to record truly representative data from one point in space.

The Temperature Sensor is a shielded, spiral-coil, bimetal element. The sensor's dual range is field adjustable from the outside of the housing to suit the requirements.

MRI MECHANICAL WEATHER STATION

FIGURE A-5

Table A-8

SPECIFICATIONS FOR MRI MECHANICAL WEATHER STATIONS

Wind Direction Damped 33-1/2" aluminum vane	Delay Distance = 8 feet (50 percent recovery) Damping Ratio = 0.5 to 0.6 Starting Threshold - less than 0.75 mph Overall Accuracy = ± 1 percent full scale
Wind Run (Speed) Fast response aluminum cups	Flow coefficient - 7.90 feet/rev Flow per recording traverse = 10 miles Response distance = 8 feet (63 percent recovery) Starting Threshold = Less than 0.5 mph Overall Accuracy = ± 2 percent
Temperature Shielded bimetal coil sensor	Range L = -90^0F to $+60^0$F Range H = -30^0F to $+120^0$F Note: Range L or H selectable by field adjustment Absolute Accuracy = ± 3^0F Relative Accuracy = ± 1^0F
Recorder Precision Escapement Time Drive	Battery-Wound Spring Motor Optional Chart Speed: 10 mm/hr or 65 days per roll 20 mm/hr or 32 days per roll Duration: 4 months Active chart width is 4" Chart Paper = plastic coasted, pressure sensitive with black trace, in 52' rolls
Batteries Temp. above $+20^0$F	Two "D" size flashlight batteries - approximate life of 65 days Two Eveready E95 run for 4 months
Temp. at -20^0F	Two Eveready E95 run for 3 months
Temp. at -40^0F	Two Eveready E95 run for 2 months

The recorder for the Mechanical Weather Station shown on Figure A-6 is driven by a precision clockwork mechanism. The battery-wound spring system is reliable over 30, 60, or 120-day operation. It maintains an accuracy of ±60 seconds per 24 hours in the ambient temperature range of +160^{0}F to -25^{0}F, and ±120 seconds in the -25^{0}F to -40^{0}F range.

The chart record is a plastic-coated, pressure-sensitive paper with black marking on a white background. It is impervious to moisture and provides a high resolution record under environmental extremes. Three-event chart paper was supplied in 52' rolls with hourly graduations of 20 mm/hr for C-b Shale Oil Tract use.

Figure A-7 shows a typical section of the chart to illustrate the format. The measurements are continuous.

A.5.1.2 Reporting Frequency and Format

The analog strip charts, illustrated in Figure A-7 were digitized by Computer Research Corporation. The digitizer provided punch-card outputs at hourly intervals for temperature, wind run, and average direction. The punched cards were input to a computerized environmental data base and subsequently to computer programs to reformat output diurnal hourly-values of temperature, wind speed, and wind direction for each month.

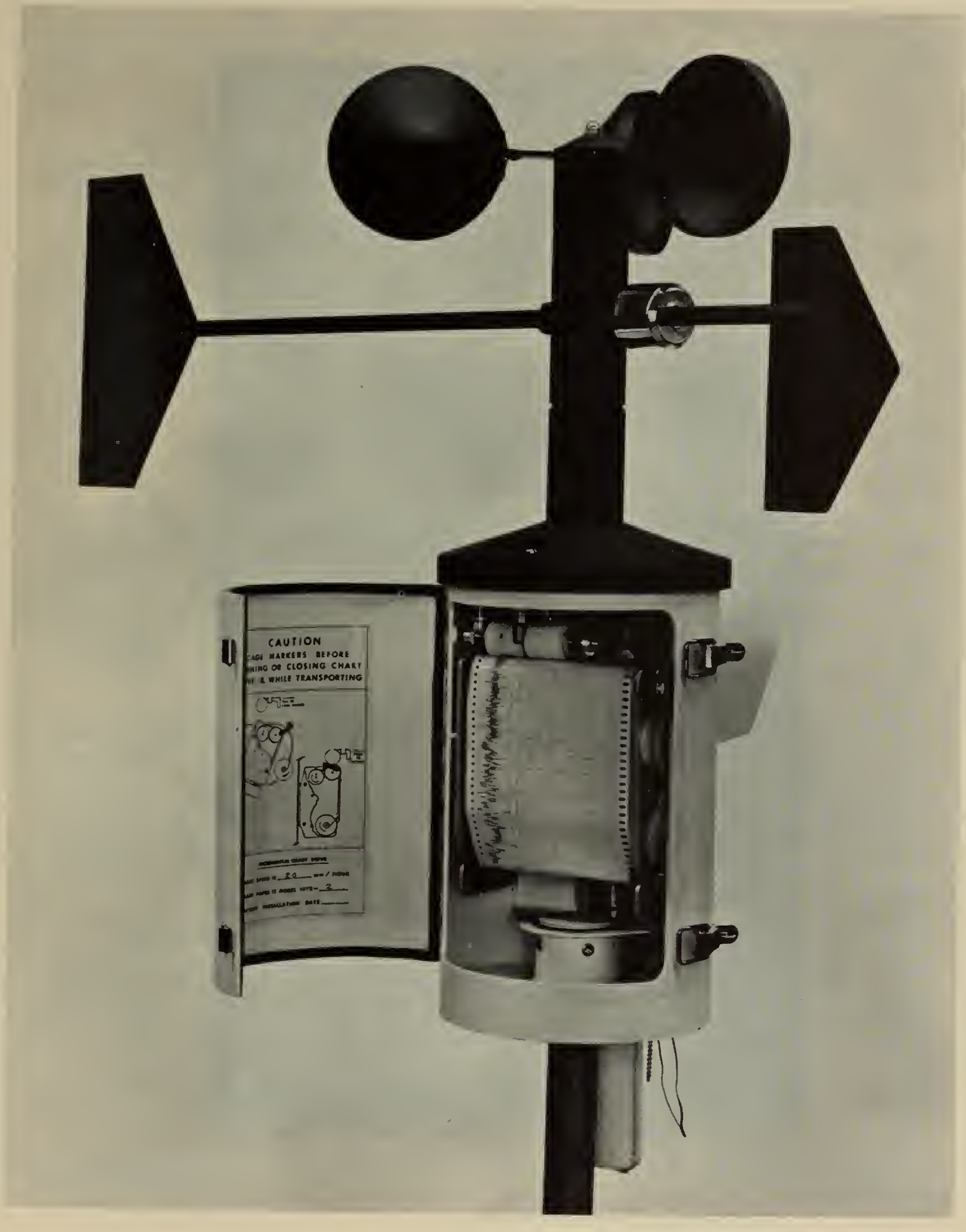
A.5.2 Quality Assurance

Quality assurance of the weather stations was achieved through frequent checks and resettings by trained technicians on the C-b Shale Oil Tract.

A.5.2.1 Calibration Technique

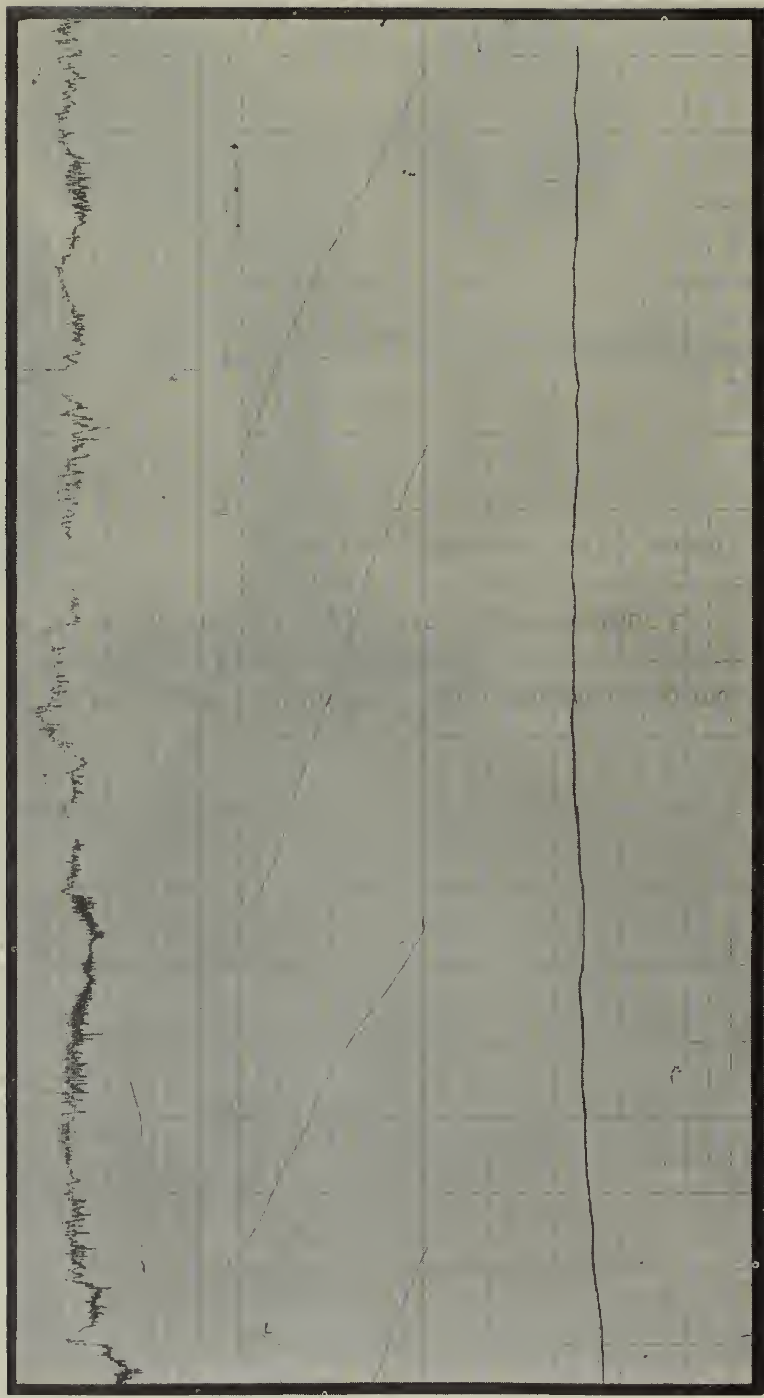
The specifications for the weather stations are shown in Table A-8.

Field calibration of the operational system was accomplished according to procedures outlined in the instrument manual. Factory calibration and recalibration on an as-required basis utilized wind tunnel and laboratory test equipment.



OPERATIONAL VIEW OF MECHANICAL WEATHER STATION

FIGURE A-6



TYPICAL MRI STRIP CHART RECORD

FIGURE A-7

A.5.2.2 Calibration Frequency

Although the specifications indicate reliable operation for periods of up to two months continuous operation on the C-b Tract demonstrated a need for frequent checks on the operational status. Weekly checks on the operation and chart speed became a necessity. A major problem developed with batteries, especially during cold weather resulting in intermittent operation and loss to time reference for the data. Table A-9 shows the failures reported in the operational logs by instrument and location. In the first sixteen months of operation two of the three instruments were returned to the factory for repair. One was returned twice. The third was operational throughout the period.

A.5.2.3 Equipment Reliability

Three instruments were installed for operation on July 2 and 3, 1975. These stations were given station location numbers of 031, 032, and 033. They were moved on April 30, 1976 to new locations designated as 041, 042, and 043. After instrument failure and factory repair Station 042 was discontinued and the instrument reactivated at a new location, 044. Station locations are shown in Figure 2-2.

An operational reliability analysis was performed based on the period from July 2, 1975 through October 30, 1976. Table A-10 summarizes the operational reliability by station and instrument numbers. "Up" time was defined as that time for which useable data were obtained from the instrument. "Down" time included some intermittent data time for which time references could not be established. The overall reliability for all stations and instruments was 84.5 percent over 16 months of operation.

Figure A-8 shows the MRI Station Data Timelines. Station 042 was discontinued on June 29, 1976 and Station 043 was discontinued on September 2, 1976. In both of these cases the stations were either operating intermittently or the instrument was sent to the factory for repair.

Table A-9

MRI WEATHER STATION

FAILURE ANALYSIS THROUGH SEPTEMBER, 1976

MRI #	Location	Problem	Days Lost Data
SN 607	031	Batteries ran down	9 (8/16-8/25)
		Batteries low, charts ran slow	7 (11/3-11/10)
		Batteries low, charts ran slow	0 (12/23)
		Same problem, batteries low in 20 days	(1/29)
		(Changed to 6V.Hot Shot batteries which alleviated the problem)	(3/30)
	041	Gained 1 hr. in 3 days	(8/6)
		Loose wire	9 (9/1-9/10)
			25
SN 707	032	Batteries down	1 (8/25-26)
		Batteries down	9 (9/6-15)
			2 (/27-29)
		Batteries down	3 (12/14-17)
			3 (1/2-5)
		Chart drive motor down	5 (1/23-27)
		In California for repairs	39 (1/28-3/8)
	033	Loose wire	7 (3/8-15)
		Stopping & starting	15 (4/4-19)
		(Stops between midnite & 9am, approx)	partial days
	043	Chart drive down intermittently	11 (8/23-9/3)
		In California for repairs	27+(9/3-10/?)
			122+
SN 706	033	Chart slow, batteries down	0 (11/26)
		Batteries down	4 (1/2-6)
		Batteries down	4 (1/25-29)
		Instrument down- undiscovered for 11 days	11 (2/9-20)
		In California for repairs	65 (2/20-4/26)
	042	Stopping & starting - chart drive?	25 (6/5-30 data unuseable)
		In California for repairs	50 (6/30-8/19)
	044	O.K. Since 8/19/76	
			159

Table A-10

MRI MECHANICAL WEATHER STATION OPERATIONAL RELIABILITY

Station Number	Data Time Interval		Instrument Number	Station Time		Time in Hours			Percent Time	
	From	To		Days	Hours	Up	Down	Total	Lost	"Up"
031	7/2/75 (1600)	4/30/76 (1600)	SN 607	303	0	6632	640	7272	8.8	93.2
032	7/2/75 (1600)	1/15/76 (1900)	SN 707	197	3	4174	557	4731	11.8	88.2
	1/15/76 (1900)	3/2/76 (1500)	No. Instr.	46	19	0	1123	1123	100.00	0
	3/2/76 (1500)	4/30/76 (1700)	Borrowed Instrument	59	2	1381	37	1418	2.26	97.7
	7/2/75 (1600)	4/30/76 (1700)	Both	303	0	5555	1717	7272	23.6	76.4
033	7/3/75 (0800)	2/19/76 (2400)	SN 706	231	17	5326	235	5561	4.2	95.8
	2/19/76 (2400)	3/15/76 (1600)	No Instr.	24	15	0	591	591	100.0	0
	3/15/76 (1600)	4/30/76 (1800)	SN 707	46	2	1054	52	1106	4.7	95.3
	7/3/75 (0800)	4/30/76 (1800)	Both	302	10	6380	878	7258	12.1	87.9
041	5/1/76 (0000)	10/31/76 (2400)	SN 607	184	0	3840	576	4416	13.0	87.0
042	5/1/76 (0000)	6/29/76 (2400)	SN 706	60	0	846	594	1440	41.3	58.7
043	5/1/76 (0000)	9/2/76 (2400)	SN 707	125	0	2635	365	3000	12.2	87.8
044	8/19/76 (1500)	10/01/76 (1500)	SN 706	42	0	765	243	1008	24.1	75.9
	10/01/76 (1500)	10/31/76 (2400)	SN 707	30	10	730	0	730	0.0	100.00
	8/19/76 (1500)	10/31/76 (2400)	Both	72	10	1495	243	1738	14.0	86.0
TOTAL FOR ALL INSTRUMENTS						27383	5013	32396	15.5	84.5

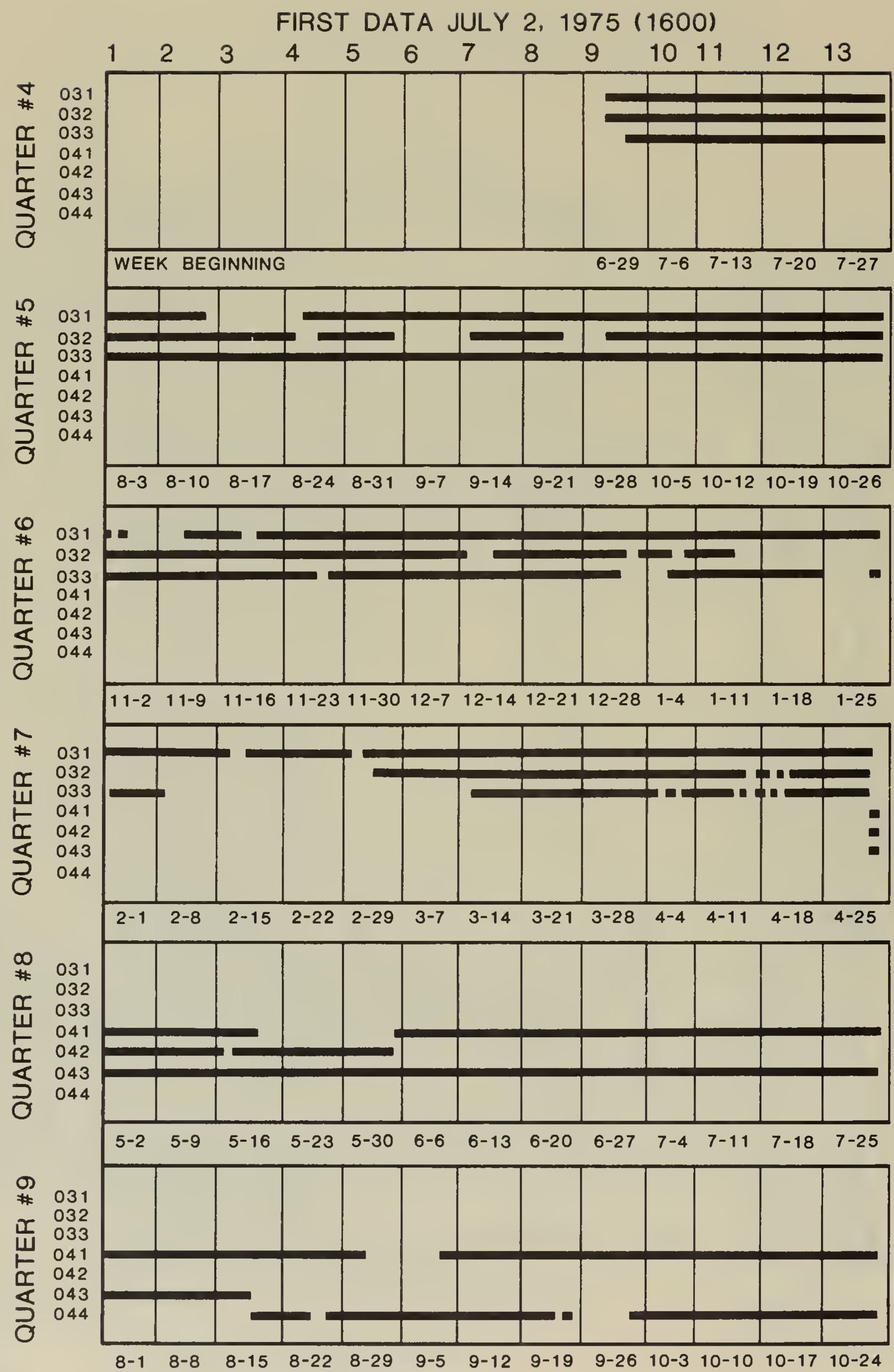


FIGURE A-8 MRI STATION DATA TIMELINE

A.6 TOSCO - Volatile Trace Metals and Particulate Studies

The program was implemented at Station 023 (November 1974) to monitor the baseline concentrations of selenium (data reported as selenium dioxide), arsenic (sampled and determined as arsine, AsH_3) and metallic mercury in air. Additionally using an Andersen sizer, particulate matter in the respirable ranges was monitored once per quarter for two years. Consideration of the first year's data indicated that the airborne concentrations of selenium at the Tract were very low and therefore monitoring for this volatile element was suspended at the end of this period. Instead, in the second year the sampling program included monitoring and determination of particulate arsenic and organic mercury concentrations in addition to the above mentioned pollutants.

A.6.1 Methodology and Quality Assurance

The sampling approach for selenium and arsine (AsH_3 included the use of an impinger containing absorbing solutions while particulate arsenic was monitored using an 8" x 10" cellulose (high purity) filter coupled to a high volume sampler. Metallic and organic mercury both were monitored in air using a special canister containing large-surfaced silver screens and specially-treated activated charcoal. An Andersen sizer was used to monitor the concentration of particulate in the respirable ranges. Table 3-28 provides brief information on sampling techniques used and analytical methods employed for each of the pollutants.

Individually each of the pollutants included in the study are described here.

A.6.1.1 Selenium

Selenium is a member of the sulfur family and therefore is known to be isomorphous with sulfur. In fact, it is reported by Stahl (1969) that where sulfur and its compounds are present, selenium is invariably found to be associated with it as a minor contaminant. Illustrative examples are earth crust (Byers 1935) and coal (EPA Doc. 650/2-74). Therefore, the presence of selenium in the environment can be usually traced to a point source containing sulfur and its compounds.

The most commonly encountered compounds of selenium in air are reported to be selenium oxide and selenium dioxide. Both oxides of selenium exhibit significant vapor pressure and therefore use of filter media for sampling results in very poor collection efficiency (Shendrikar 1974). However, the consideration of chemical properties of oxides of selenium indicates their fair degree of solubility in water at room temperature. Atmospheric reactions due to presence of humidity in the air are reported to convert emitted selenium oxides into selenic and selenious acids. Both these compounds are soluble in water. Hence, water seems to be the obvious choice for the collection of airborne selenium.

Therefore, an impinger containing a known amount of water (Shrendrikar and West 1973) was used to collect selenium from the air. Thus, regardless of any chemical form of selenium, sampling was achieved with maximum efficiency.

Figure A-9 depicts a typical impinger and sampling assembly used for the monitoring of selenium at the Tract.

The typical selenium sampling involved passing of the regional air (at about 15 feet height) through the impinger that contained a known volume (10 ml) of water. The air was passed through the impinger at known velocity and for a fixed length of time. At the end of the sampling, the water from the impinger was made up to the original volume (to compensate for the evaporative losses) and transferred into a 25 ml vial, refrigerated and brought back to the laboratory for analysis. At the laboratory selenium was determined using a well established analytical method (Shrendrikar 1974, West and Ramkrishna 1968). Essentially the method consists of complexing selenium with sulfide. The resulting seleno-sulfide $(Se\text{-}S)^2$ complex is very stable and catalytically reduces methylene-blue quantitatively. The analytical method used is simple, sensitive, and almost free of any interferences. Only copper is known to interfere in this method, but none of the water soluble copper compounds are expected to be present in the C-b air. The sensitivity of the method is 0.05 μg and the precision for number of determinations and standard deviation are given in Table A-11.

Basically sample analysis involved utilization of selenium standards to obtain a calibration curve in the ranges of 0.1 to 1 μg. Subsequently this curve was used to obtain the concentration of selenium in the air samples collected in the water at the C-b Tract. Refrigeration of samples after their collection was routinely practiced to maintain the integrity of samples.

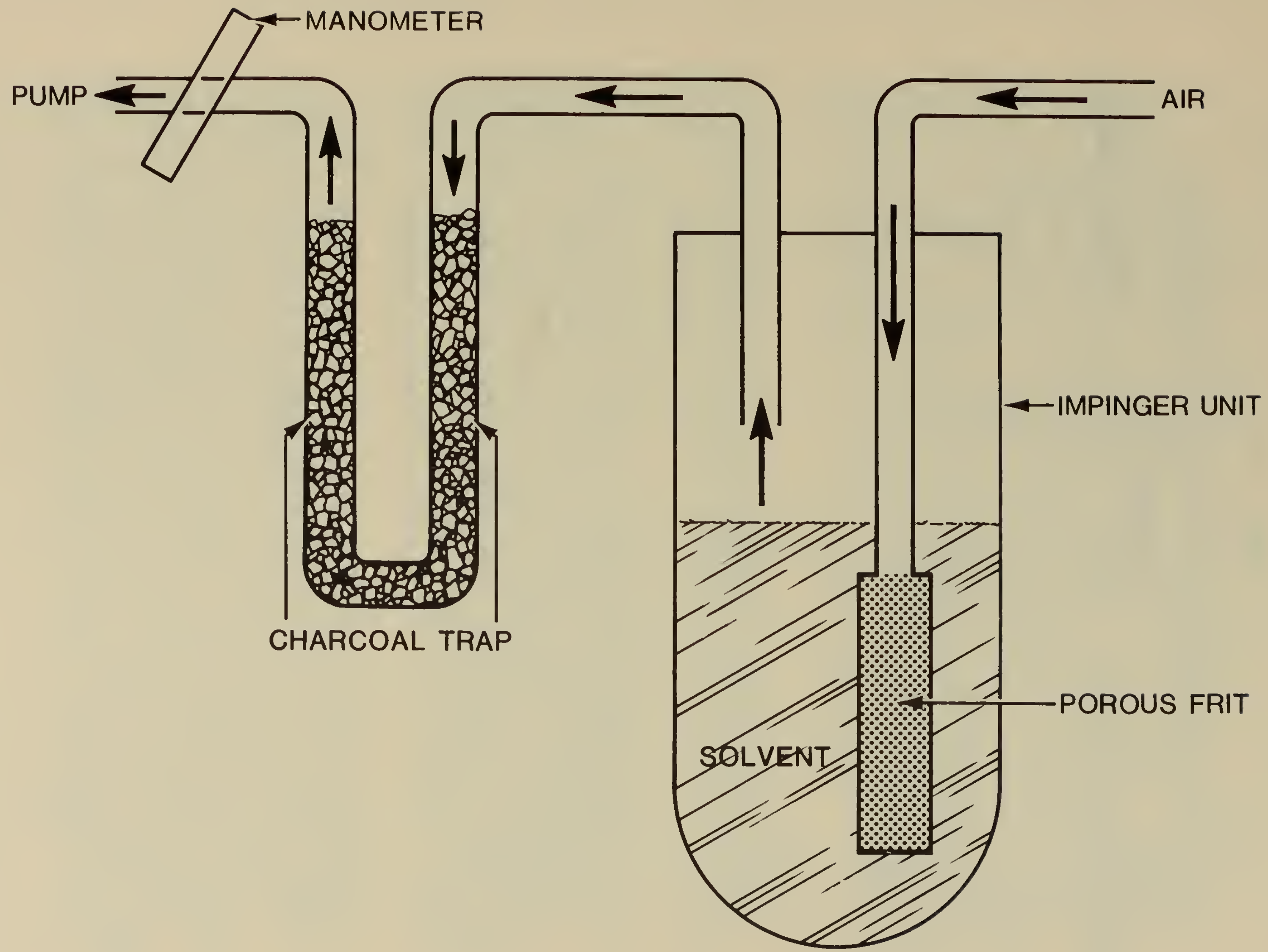


FIGURE A-9 DIAGRAM OF A TYPICAL IMPINGER USED IN AIR SAMPLING

Table A-11

PRECISION OF THE CATALYTIC METHOD FOR SELENIUM

Number of Determinations	Selenium, μg Taken	Selenium, μg Found	Standard Deviation
8	1.0	1.09	0.25
8	0.5	0.49	0.02
8	0.2	0.2	0.01

On the sampling days, notes were routinely made of existing meteorological conditions; hence air volumes for each sample were corrected for barometric pressure and temperature.

A.6.1.2 Mercury

Mercury, another pollutant of considerable concern in terms of environmental health effects (Kitamura 1971, Clarkson 1965) has been monitored in air at the Tract for two years. A sampling approach capable of differentiating the chemical forms of mercury was chosen since chemical forms of any element have been known to be a prime factor for accessing toxicity and carcinogenicity. For example metallic mercury (Hg^0) is reported to be toxic while (Hg^{+2}) is not toxic. Similarly organic mercury compounds are also proven to have toxic effects on humans and animals (Stahl 1969). Additionally, since mercury appeared to be one of the few elements that is likely to be emitted in the form of an aerosol in the air during retorting of oil shale at 950°F, it was monitored for baseline concentrations at the Tract. Oil shale is reported to contain on the average of 0.1 to 0.35 ppm of mercury.

In the first year of the program metallic mercury (Hg^0) was monitored. However second year monitoring included elemental mercury (Hg^0) and also organic compounds of mercury such as ethyl, methyl, phenyl mercury, etc.

Airborne mercury (metallic only, Hg^0) concentrations were determined each quarter for the period of two years using a canister (see Figure A-10) that contained large surfaced silver screens. The canister (supplied by the Columbia Scientific Corporation, Austin, Texas) together with silver screens (Perkin-Elmer Corporation, Norwich, Connecticut) were used for collecting airborne mercury. Coconut charcoal (activated) of 40-60 mesh was placed in the two compartments of the canister to collect organic mercury compounds present in the air.

The sample preparation steps involved removing contaminants from the five silver screens (cut to the size to fit snugly on each side of the two compartments) and activated charcoal (about 50 gms.). This was achieved by equilibrating the screens and the charcoal in a solution of 1:1 nitric acid (1 part nitric acid : 1 part water) for five minutes. After this silver screens and charcoal were washed with doubly-distilled water until free of nitric acid and dried in an oven at 105°C for thirty minutes. Then all of the five silver screens were weighed individually and four of them were placed on the four sides of the two compartments of the canister. The fifth silver screen was then packed in an air-tight zip-lock bag and set aside to serve as a blank.

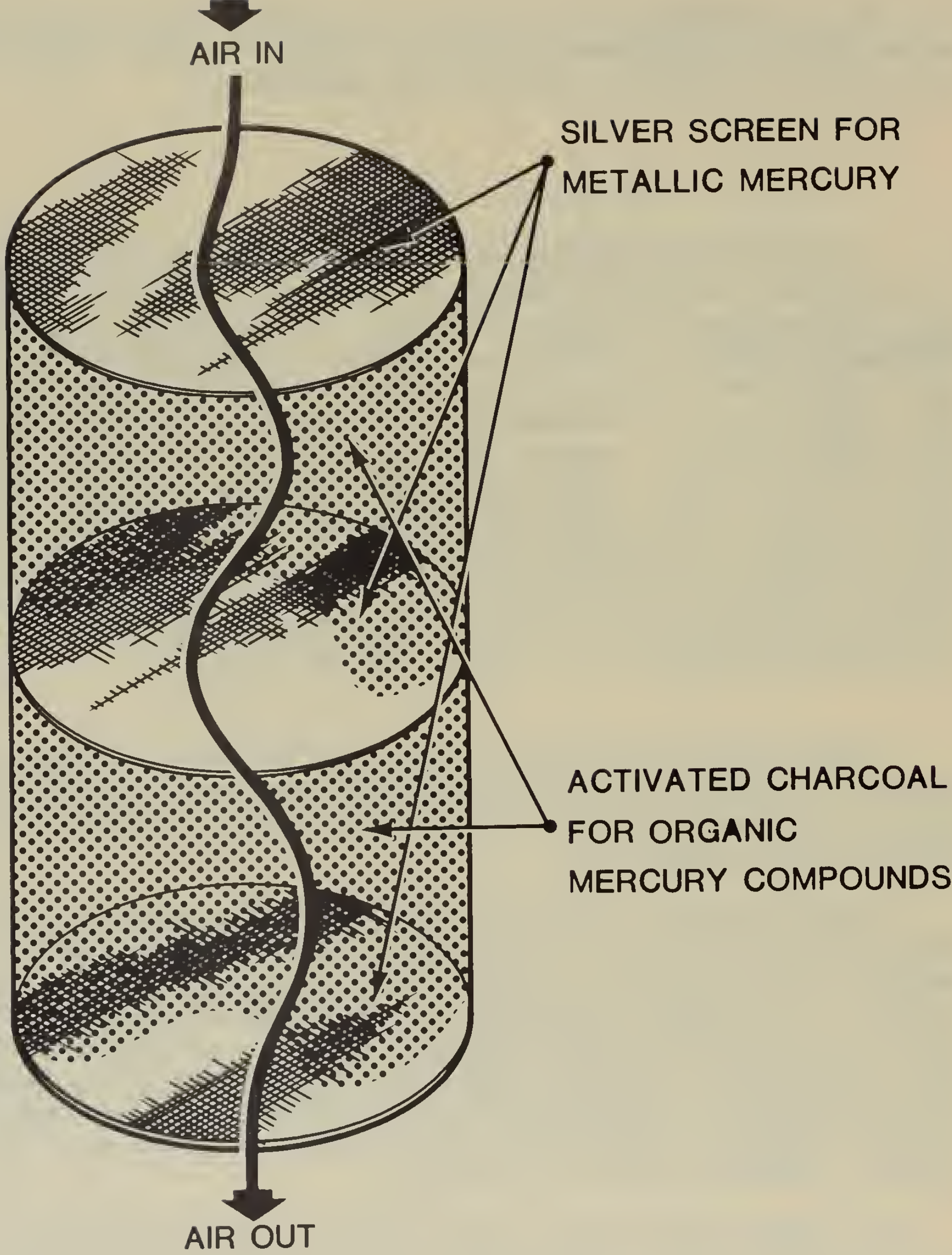


FIGURE A-10

SAMPLING ASSEMBLY FOR AIR MONITORING OF METALLIC AND ORGANIC MERCURY COMPOUNDS

Similarly for the collection of organic mercury compounds, a weighed portion (10 gms.) of washed charcoal was placed in each of the two compartments (Figure A-10). Separately a charcoal blank (10 mgs.) was packed in a zip-lock bag. The entire canister was carried to the Tract in an air-tight bag for sampling.

For sampling the air in the Tract, the canister was placed at the bottom of the high volume sampler and air was pulled through at a fixed velocity for a certain length of time. After sampling, the canister was packed again in an air-tight bag and brought back to the TOSCO Laboratories. All the mercury analyses were performed by the Commercial Testing Laboratory, Golden, Colorado.

The analytical method (Knauer and Milliman 1975) for the metallic mercury determination involved heating the silver screens to 400^{0}C in a closed glass tube. Quantification was achieved by passing the deamalgamated mercury vapours into a silica tube placed in the path of a mercury hollow cathode of an atomic absorption spectrometer. Similarly total and inorganic mercury present on the activated charcoal were determined by deadsorbing it in a known volume of nitric acid and potassium permanganate solution and in 6 N hydrochloric acid solution respectively. Deadsorption involved equilibrating a known weight of charcoal with each of these solutions for five minutes and filtering to known volumes. Mercury in these solutions was determined by the addition of 1 ml solution of 10 percent stannous chloride in concentrated hydrochloric acid. This step evolved mercury which then was passed into a silica tube placed in the path of a mercury hollow cathode of an atomic absorption spectrometer. Subtracting the value of total inorganic mercury from the value of total mercury gave the concentration of organic mercury present in the sample.

This flameless atomic absorption method for the determination of mercury has a sensitivity of 0.0001 μg. A calibration curve using mercury standards was always prepared to find the mercury concentrations in the samples. The method has essentially no interference. Only high levels of chlorine and sulfur dioxide, if present, will poison the silver screens or canister. Ambient levels of hydrogen sulfide, sulfur dioxide and nitrogen dioxide are reported to have no effect. Large concentrations (above 13 $\mu g/m^3$) of hydrogen sulfide show an interference; however at no time during sampling were such high concentrations recorded. Acetone, benzene, and ethanol also do not interfere.

The recovery of mercury from the silver canister is known to be at least 98 percent at 400°C. The precision of the method has been reported to be about 10 percent and the relative standard deviation for ambient mercury vapor concentrations is about 0.3 $\mu g/m^3$.

Mercury present in the air is most likely to be elemental mercury (having high vapor pressure), and hence, it amalgamates very efficiently with silver or gold. Therefore, this sampling technique for airborne mercury is very efficient.

A.6.1.3 Arsenic

Arsenic, another pollutant of health consequences (Sullivan 1969) was also monitored in the air at the Tract. First year monitoring involved determination of arsine (AsH_3) concentrations; in the second year both arsine and particulate arsenic were monitored each quarter. For particulate arsenic a simple high volume sampler equipped with an 8" x 10" cellulose filter was used. The sampling time was 24 hours. This sampling approach was supposed to account for all particulate forms of arsenic present in the air with the exception of arsine, which is gaseous at room temperature and pressure.

In sampling conducted in 1975, air containing arsine was pulled at a fixed velocity through an impinger that contained a pyridine dissolved 0.1 percent of silver diethyldithiocarbamate. The color intensity of the resulting red-color solution was measured (Buchanan 1962) using Spectronic 20 at 540 nm immediately after sampling was completed. This step was essential since laboratory tests had shown that an arsenic complex of diethylidithiocarbamate was unstable. This method (Buchanan 1962) is specific for arsine with a sensitivity of 0.5 μg and a relative standard deviation of only 13.8 percent. Reported interference is from hydrogen sulfide. This was eliminated by passing air through cotton impregnated with lead acetate solution and then into silver diethyldithiocarbamate.

The analytical determination of particulate arsenic involved its extraction (extraction time 30 minutes) with 6 N hydrochloric acid solution from an 8" x 10" filter. The extract was used to determine arsenic levels using the Gutzeit method (Jay 1956). This involves generation of arsine from the extract solution by addition of granular zinc and sulfuric acid. The evolved arsine is passed through filter paper impregnated with mercury bromide. The contact point on the filter results in a yellow stain the intensity of which is compared visually with standard stains obtained using standard arsenic solutions. The sensitivity of the method is 0.05 μg.

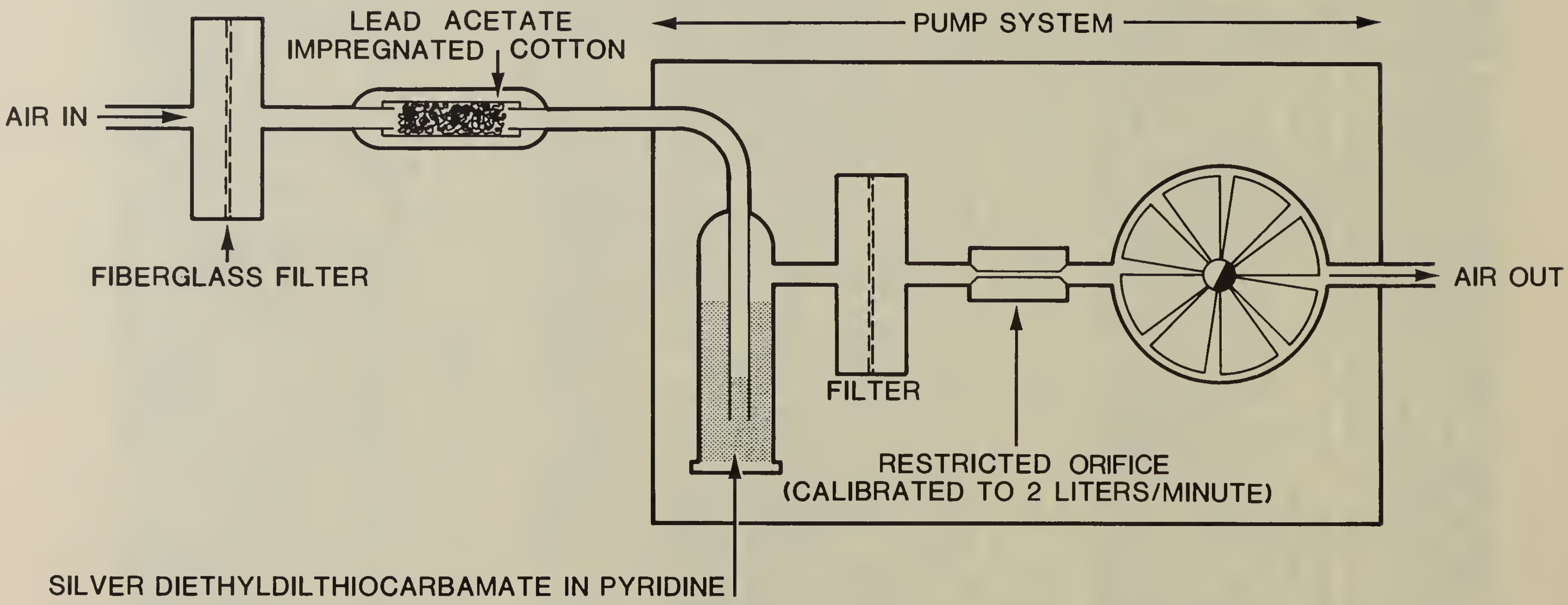
Before initiating this program, a literature search was directed to select the best possible methodologies for determination of each of the parameters. After the literature search, it became apparent that there are not many field methods that can specifically determine arsine. Therefore, because of an almost no-choice situation, the method utilizing silver diethyldithiocarbamate was chosen. This method evidently has the following

disadvantages: (a) solvent evaporative losses from the impinger exist due to passing of air, (b) no detailed investigation of interferences has been made, (c) instability of arsenic complex with silver diethyldithiocarbamate exists with respect to UV light, (d) effect of the particulate matter present in the environment on the kinetics of chemical reaction between arsine and the organic reagent used is unknown, (e) limitations exist on the sampling time. Advantages are: (1) the reagent reacts specifically with arsine and no other compounds of arsenic, (2) the method has been in use for at least 3-4 decades, (3) it is a sensitive method and can be used for field sampling. At the present time there are no universally accepted methods for determination of arsine, i.e., all techniques are still of an R and D nature. As a result of a meeting with the EPA in April 1976, it was decided to modify the sampling procedure somewhat as indicated on Figure A-11.

This procedural modification to the third and fourth quarter samplings of the second year also involved consideration that particulate matter might be causing interference in the chemical reaction between arsine and silver diethyldithiocarbamate. Therefore sampling incorporated a prefilter with known collection efficiency supplied by the EPA in the sampling assembly to prevent airborne particulate matter from reaching the impinger solution. With this sampling arrangement air was passed through the prefilter, then through cotton impregnated with lead acetate, then through an impinger containing a known volume of silver diethyldithiocarbamate solution and finally to exhaust. The sampling time was one hour and rate of sampling was 2 litres per minute. Immediately after the sampling the solution of silver diethyldithiocarbamate was transferred to test tubes and arsine concentration measurements were performed on site using a Spectronic 20 and wavelength of 540 nm. The next sample for arsine was collected immediately, using the same sampling arrangement, except that no prefilter was used. Samples at various times of day have been collected using this kind of arrangement and sequences.

A.6.1.4 Particulate Matter

The purpose of this sampling was to determine the fraction of particulate matter in the respirable ranges. This study is completely unrelated to the study of particulate arsenic. Sampling was achieved by using the Andersen 2000 sampler (see Figure A-12b) which conveniently fits on the head of the high volume sampler (see Figure A-12a) at Station 023. The Andersen head attachment to the high volume sampler is a multi-stage, multi-jet cascade impactor. It is made of five aluminum plates separated by neoprene rubber gaskets. The standard 8" x 10" high volume glass-fiber filter functions as a backup filter. Each plate contains 300 equally-sized holes. The holes are aligned so that the air



SAMPLING ARRANGEMENT FOR COLLECTION OF AIRBORNE ARSINE AT THE C-B TRACT

FIGURE A-11

a. SIDE-BY-SIDE HIGH VOLUME SAMPLERS (ONE OPENED AND ONE CLOSED)

b. ANDERSEN PARTICLE SIZER INSTALLED IN THE HIGH-VOLUME SAMPLER

SAMPLING ARRANGEMENT FOR PARTICULATE SIZE DISTRIBUTIONS
FIGURE A-12

streams through the holes are directed at the surfaces of the plate below. The diameter of the holes decreases from plates one to four. Plates are covered with circular glass filters which have holes aligning with the holes in the plates supporting them. The mass of particulates, on a particular stage or plate, is determined by the usual gravimetric procedure at a known relative humidity (i.e., difference in weights is determined by using an analytical balance). The filters resting on plates 2, 3, 4, 5 and the backup filter correspond respectively to aerodynamic diameters of 7.0 microns and above, 3.3 to 7 microns, 2.0 to 3.3 microns, 1.1 to 2.0 microns and 0.01 to 1.1 microns.

Each dust fraction was calculated using the following formula:

$$\mu g/m^3 = \frac{(W_2 - W_1)\ 1000}{V}$$

W_1 = weight (gms) of fiber glass paper before sampling

W_2 = weight (gms) of fiber glass paper after sampling

V = total volume of air pulled in (liters)

Note: Filters before sampling and after sampling were stored in a constant humidity chamber at least 48 hours to attain humidity equilibrium.

Table A-12 includes meteorological conditions recorded for each quarter for the two years of the program.

Table A-12

METEOROLOGICAL* DATA
ON THE SAMPLING DATES FOR VOLATILE TRACE METALS

1st year Quarter	Recording Date	Temp, (^{0}F)	Wind Velocity (mph)	Wind Direction	Relative Humidity (%)	General
1st	November 22, 1974	50	15	Southwest	38	The day was clear, cold and reasonably sunny
2nd	January 27, 1975	29	5	Northwest	73	Partly clear snow on the ground
3rd	April 24, 1975	50	6[1]	Southwest	49	The day was clear and sunny
4th	July 25, 1975	71	5	Southeast	55	The day was clear and sunny

MEAN TEMPERATURE 50

MEAN WIND VELOCITY 7.75

MEAN RELATIVE HUMIDITY 53.75%

*As recorded at Trailer No. 023

[1]See note 3 on Table 3-18

Table A-12 (Continued)

METEOROLOGICAL* DATA
ON THE SAMPLING DATES FOR VOLATILE TRACE METALS

2nd year Quarter	Recording Date	Temp, (^{0}F)	Wind Velocity (mph)	Wind Direction	Relative Humidity (%)	General
1st	January 22, 1976	29	1	Southeast	43	The day was sunny but cold with snow on the ground
	January 23, 1976	38	13	Northwest	41	The day was sunny but cold with snow on the ground
2nd	March 17, 1976	46	3	Southwest	37	The day was partly cloudy
	March 18, 1976	49	16	Southwest	37	The day was sunny but windy and cold
3rd	June 15, 1976	52	3	East	45	The day was sunny
	June 16, 1976	64	16	Southeast	29	The day was partly cloudy and windy
4th	September 1, 1976	63	5	North	41	The day was sunny

MEAN TEMPERATURE	49
MEAN WIND VELOCITY	8
MEAN RELATIVE HUMIDITY	39

*As recorded at trailer No. 023

A.7 Dames & Moore Visibility Studies

A.7.1 Methodology

A.7.1.1 Terminology

The terms visibility and visual range have been interchangeably used for several years. Their common usage is to signify the distance that something can be seen. Following Middleton (1952), the terminology of this report distinguishes between visual range and visibility. Visual range is used within a narrow sense of the concept and visibility is used in a broader context.

Visual Range is defined in the following way: As an object is moved through the atmosphere toward the horizon sky, the contrast between the object and the sky decreases. At some distance the contrast becomes too small to be detected by the observer, and the object vanishes. The distance from the observer to the object at the vanishing point is the Visual Range. The term visual range is used in this report when referring to a maximum distance of sight along a single path length.

Visual range can vary in time and by direction. It is very common for a view to the west to differ significantly from say a view to the south when comparing concurrent measurements of visual range. It is often noticed for a fixed direction that the visual range changes throughout the day. Such directional and time dependences would also be detected by the human eye. Thus, specific situations exist for each direction at a certain time. At any given time there is a more general or synoptic situation created by the directional dependence of visual range. Finally, there is the general long-term climatological situation that exists because of changes in visual range over all directions over a long period of time.

Visibility is used as a general term, descriptive of the general situations discussed above. As such it definitely has the connotation of a general state of clarity of the air. However, it does not represent an entirely subjective concept because of its connection with a given quantifiable set of values for visual range. In this report visibility is used as an areal descriptor. It will refer to an average of all directional visual range observations over specified periods of time. It will also

be used in a qualitative sense in textual description of the clarity of the air as evaluated from overviews of visual range data.

Generalized Visibility, for example, is defined as the visual range averaged over all views for time periods of seasonal and annual extent.

A.7.1.2 Theory of the Method

The method employed in the documentation of visibility incorporates the technique of photographic photometry to measure the attenuation of light by atmospheric scattering. Unlike the integrating nephelometer which relies on the analog response of a photoelectric detector to record light attenuation, photographic photometry employs photographic film as the recording medium. A discussion of the equations used in this study is presented in Section A.7.4.

Photographic measurements of the attenuation of light by atmospheric scattering have been made for many years in various ways and for different reasons. The technique is one method of turbidity measurement and has been applied to turbidity of water as well as turbidity of air. The technique has been used, for example, by the Lamont Geological Laboratories to measure undersea turbidity (Eittriem 1969). Steffans (1949) developed the basic equations and theory necessary to apply photography to the study of visibility through the atmosphere. Steffans demonstrated that a camera can be used as an instrument for measurement of visual range (visibility) and that a camera has certain advantages over the human eye: (1) a film provides a permanent record, (2) relative light intensities can be measured accurately, (3) a film can be calibrated for its reaction to light, (4) the camera, if maintained in good condition, does not experience focus changes, fatigue or deterioration in its repeatability, and (5) a telephoto lens allows measurements through long atmospheric path lengths.

Experience shows that if a black object of sufficient size is moved through the atmosphere away from an observer, the object will appear to become brighter as the distance from the observer increases. This increase in brightness is the result of light being scattered toward the observer by small aerosol particules suspended in the air between the object and the observer. If the same object were moved away from the observer through a vacuum, it would remain black and would disappear only when its apparent size could no longer be resolved by the eye of the observer.

The casual observer of western scenery has noticed the changing shades of gray in successively more distant mountain ranges. This effect demonstrates the attenuation of light through air that

contains particulate matter; it is this effect that is detected on film in the photographic measurement of visual range.

A.7.1.3 Data Sampling and Reduction Techniques

A.7.1.3.1 Data Collection

The photographic measurements of visual range were accomplished with a 35 mm camera attached to an 800 mm refractive lens shown in Figure A-13. Black and white panchromatic film was used to photograph the objects in each view at prescribed hours every sixth day. In addition, color slides were taken concurrently with a normal focal-length lens and 35 mm camera to pictorially record the sky and weather conditions in each view during the hours of photography, i.e., 0830, 0930, 1030, 1130, 1300, 1400, and 1500 MST. Each roll of film used was identified at the beginning of each scheduled day of photography with a photograph of a card identifying the film roll with the date, location, and project number.

To ensure constancy of operation in the field, the photographer followed a standard-operating-procedure check list which detailed the steps to be taken for the collection of visual range data. To preclude the possibility that the wrong objects would be photographed, reference points near the visibility shelter were identified to assist the photographer in the alignment of the camera and lens. In addition reference points seen through the lens were used to center the objects in each view, although if improperly centered, visual range measurements could still be made; the relative centering of the objects in the camera had no effect on the calculation of visual range. During the year long study, only one hour of data for one view was lost due to improper alignment of the camera and lens in a view. In addition to the photography, pertinent visibility information was recorded each hour in a Site Log by the photographer to supplement the photographic study. Each hour, notations were made on the local weather conditions, restrictions to vision and view usability, with additional comments for any unusual occurrences such as camera malfunctions or site visits. At the completion of the day, the film was removed from the camera and stored in a cool, dry location until being mailed in insulated containers to the laboratory for development.

A.7.1.3.2 Data Reduction

Film Processing - Processing of the black and white film was accomplished in the Dames & Moore Laboratory under closely controlled conditions. Photographic chemicals were frequently replaced

VISIBILITY SHELTER
PICEANCE CREEK BASIN, COLORADO
SEPTEMBER, 1975 - SEPTEMBER, 1976

FIGURE A-13

and processing temperatures held to within ±1°C. Color film was not used to provide numerical data; thus it was developed through commercial sources.

Prior to development of the black and white film, the leading end of each film roll was exposed to a calibrated series of eleven different light intensities. Each film roll was exposed to these light intensities in a Kodak Process Control Sensitometer Model 101, illustrated in Figure A-14.

Once development of the film roll was complete, the densities of the eleven steps, referred to as a sensitometric strip, were obtained with a MacBeth TD504 Densitometer, also illustrated in Figure A-14. These densities, when plotted versus the logarithm of the exposure, provide a characteristic curve for a particular film roll. The characteristic curve provides the functional relation between exposure and image density.

A.7.1.3.3 Visual Range Calculations

In any photographic negative, the presence of an image is due to contrasts in light reflected by the several objects in the picture; this light enters the camera and sensitizes the film. The image on the film is created by an exposure, E, of the film proportional to the intensity of light, I, from the object. The ratio of light intensities from two objects in the same frame can be obtained from the measured densities of the two images and the characteristic curve. For example, suppose D_1 and D_2 are the image densities of two objects in the same frame. From the characteristic curve, values can be read for log E_1 and log E_2 corresponding to the image densities D_1 and D_2. The ratio of light intensities I_1 and I_2 from the two objects is:

$$I_1/I_2 = E_1/E_2$$

Steffan's method of computing visual range includes choosing the horizon sky as one of the objects. This may be denoted by replacing the subscript "2" with "∞." Object 1 at a distance, x, from the camera produces an image of density D_x. The horizon produces an image of density D_∞. The ratio of light intensities I_x/I_∞ is determined in the manner described above. The visual range, VR, is computed from the formula:

$$VR = Mx/\ln(1-I_x/I_\infty)$$

where M is related to the ability of the eye to detect contrast. It has been found that the "average" eye is capable of detecting

SENSITOMETER

DENSITOMETER

LABORATORY EQUIPMENT FOR THE VISIBILITY STUDY

FIGURE A-14

contrasts no less than 2 percent. For such an average eye, M has the numerical value of 3.912. A discussion of the equation is included in Section A.7.4.1.

The above equation for visual range implies that the object is black. In practice the objects are dark, but not black. However, the equations can be modified to account for the non-zero reflectance of the objects (Section A.7.4.2, equation #13). Each object was examined from the air to estimate the type and amount of vegetative cover from which an albedo (reflectance) could be determined. Albedoes of 0.15 typically were used during the warmer months of the year when no accumulations of snow existed. Snow accumulations during the winter, however, required additional adjustments to be made in the albedo of each object. The resulting albedo was estimated using the original albedo of the object modified by the relative contribution of the snow. The albedo values used for the original object surfaces and for the additional snow cover were based on the special reflectance of snow and various soil types listed in the Handbook of Geophysics and Space Environments (Valley 1965). The resultant albedoes during the winter ranged from 0.15 to 0.70. The increase in albedo of the objects during the winter did not significantly alter the calculated visual ranges, however.

A.7.2 Quality Assurance

A.7.2.1 Calibration Techniques and Frequency

The calibration of each of the parameters used in the calculations of visual range and the experience gained from previous studies all serve to ensure the reliability of the data.

Parameters used in the calculation of the visual range such as the object distances, for example, were measured by two methods:

1. Line of sight aircraft flights between the camera site and each object and the identification of each object on a United States Geological Survey (USGS) topographic map.

2. Measurement of the object-to-camera distances on USGS topographic maps.

The two methods used to measure camera-to-object distances generally agreed within 5 percent although the distances obtained from the USGS maps always took precedence.

The characteristic curve, which defines the exposure-film density relation, was developed from a sensitometric strip placed

on each film roll, as described previously. The sensitometer used to install this strip was factory calibrated, and the light source replaced at the manufacturer's recommended intervals.

The use of this strip also provided a means to monitor the developing process. Processing of the film was closely monitored and the results of the developing technique can be evaluated based on the average characteristic curve and the standard deviations obtained from the 63 rolls of film obtained during the year. The characteristic curve illustrated in Figure A-15 represents the average density value obtained from each of the 11 steps found on the sensitometric strip; the vertical bars at each step number represent a range of two standard deviations around the mean density. This curve is shown only to illustrate the constancy of the developing process; however, each film roll had its own curve to define the individual characteristics of that roll.

Measurements of the density values on each film roll were obtained with a densitometer calibrated with a step wedge similar to the sensitometric strip. The densitometer was calibrated before and after reading image densities from each film roll, but typically required no adjustments. The repeatability of the instrument is approximately ±.01 density units.

A.7.2.2 Equipment Reliability

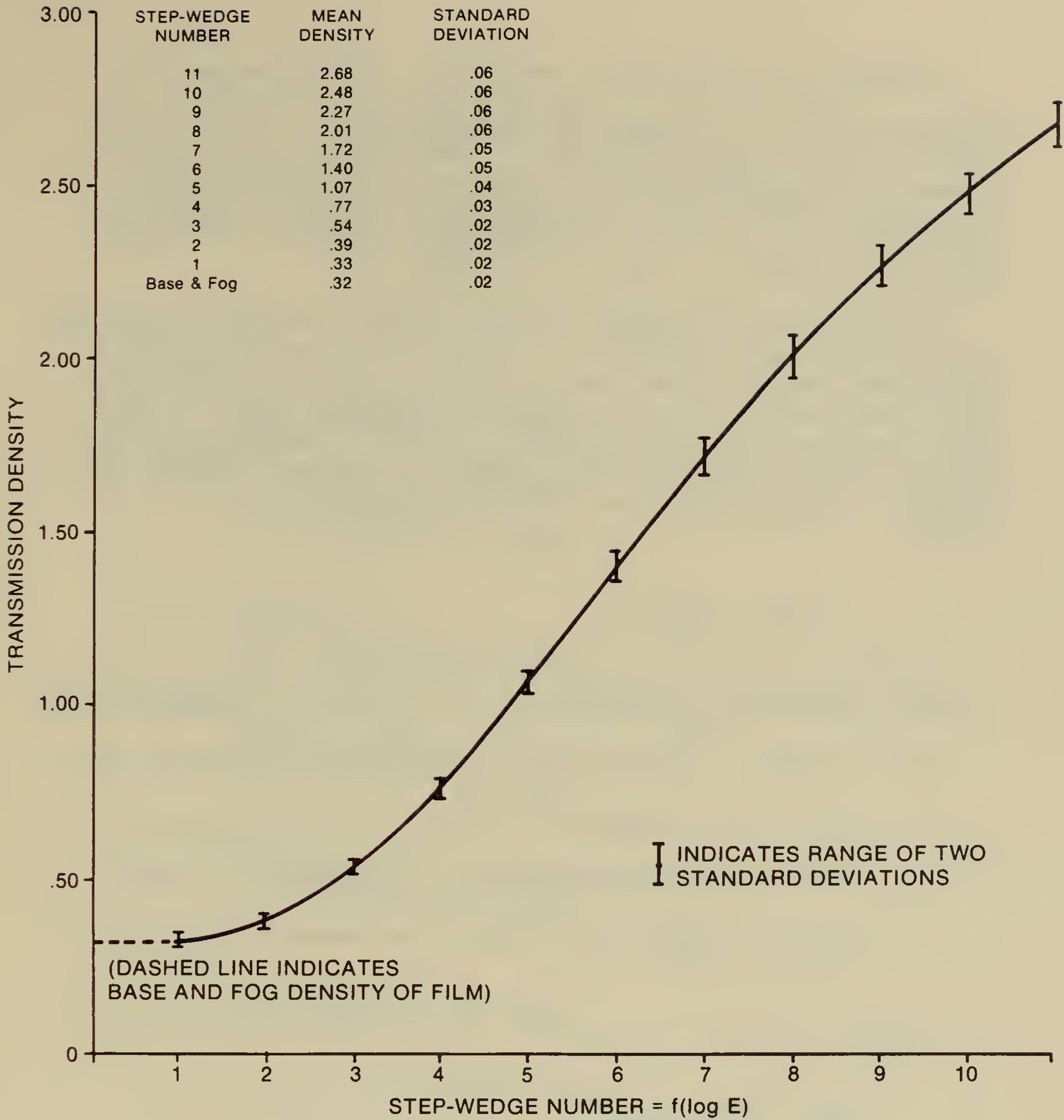
The field and laboratory equipment used in the documentation of visibility required only minor maintenance and repair during the year. That equipment which required repair was replaced within a week to ensure the continuation of the collection and/or reduction of visibility data. The photographic equipment used in the field required only minor repair during the year. No problems were encountered with the lens; however, failure of the color camera to properly advance the film required its replacement approximately half-way through the study.

Laboratory equipment used in the study was extremely reliable. No problems were encountered with the sensitometer and only one minor problem with the densitometer. During the reduction of data in the summer quarter, the densitometer required minor repairs which resulted in no loss of data. These repairs were performed by an authorized MacBeth service center (manufacturer of the instrument) within a three-day period.

A.7.3 Data Presentation

A.7.3.1 Reporting Frequency

During the 1975-76 monitoring period, visual range measurements were made during 61 scheduled days of photography and two



AVERAGE CHARACTERISTIC CURVE
FOR PLUS-X PANCHROMATIC FILM
PICEANCE CREEK BASIN, COLORADO
SEPTEMBER, 1975 - SEPTEMBER, 1976

FIGURE A-15

half-day practice sessions. On several occasions passing snowstorms or rainshowers restricted the photography of the objects; however, of the planned 1732 visual range measurements, 1548 were obtained for an 89 percent recovery. No days occurred in which measurements were not obtained for views due to inaccessibility of the site.

Reporting of the results obtained during the year-long study was conducted on a quarterly or seasonal basis and discussed means, maximums, minimums, and other statistical descriptors of the visual range. Also discussed was the generalized visibility which described the areal visibility in the Piceance Creek basin based on visual ranges obtained from all views and hours in each season. This descriptor and others are included in this final report.

A.7.3.2 Format

The results of the visual range measurements and their statistical analysis are presented in this report as explained below:

- Daily basis: Discussion of visual ranges obtained per day.

    1. Mean - for composite of views

    2. Hourly maximum and minimum - for composite of views

    3. Trends - discussion of variations in mean visual range - for each view

- Monthly basis: Discussion of visual ranges obtained per month.

    1. Mean - for composite of views

    2. Hourly maximum and minimum - for composite of views

    3. Distribution - for composite of views

- Seasonal basis: Discussion of visual ranges obtained during the season.

    1. Mean - for each view
       - for composite of views

    2. Hourly maximum and minimum
       - for each view
       - for composite of views

3. Five percentile: 95 percent of observations exceeded this value - for each view
   - for composite of views

4. Standard deviation - measure of the dispersion of a normal frequency distribution
   - for each view
   - for composite of views

. Annual basis:

1. Mean - for each view
   - for composite of views

2. Hourly maximum and minimum
   - for each view
   - for composite of views

3. Five percentile
   - for each view
   - for composite of views

4. Standard deviation
   - for each view
   - for composite of views

5. Distribution
   - for each view
   - for composite of views

6. Trends
   - for each view
   - for composite of views

A.7.4 Supporting Equation Derivations and Examples

A.7.4.1 Theory of Visual Range

A phenomenological theory of vision in the atmosphere is presented here. The treatment is phenomenological in that the physics of light transmission through a material medium is assumed to be contained entirely in two bulk properties: extinction coefficient and reflectance.

Consider a plane object of known reflectance A_0 placed at a distance x from the observer and under a uniformly illuminated sky. The intensity of light, I_0, reflected by the body is:

$$I_0 = A_0 I_i$$

where I_i is the light incident on the surface of the body. Let I_x denote the total intensity of light reflected toward the observer from the direction of the body a distance x meters away. The intensity I will consist of I_o modified by a scattering factor plus the so-called air light. Air light is light reaching the observer from all other points in the atmosphere via multiple scattering into the light path between object and observer. If the observer were to approach the object, then I_x would approach I_o.

Under the above assumptions it may further be supposed that light is scattered out of the light path on a net basis proportional to the amount of light present at each point of the path. The constant of proportionality is called the coefficient of extinction. It may then be shown that

$$(I_x - I_\infty) = (I_o - I_\infty) \exp(-kx) \quad (1)$$

where I_∞ is the limit of I_x and x approaches infinity and k is the coefficient of extinction.

The extinction coefficient depends on the concentration and size of various particles suspended in the atmosphere.

In practice, I_∞ is taken to be the intensity of the background horizon next to the object. A black object is one for which I_o vanishes. Thus, if the contrast between a black object, at a known distance x, and the adjacent horizon can be measured, k can be determined. Although any object of known I_o can be used, black objects are most useful since, for them, I_o vanishes.

The visual range is connected to the scattering coefficient by recognizing a limitation of the human eye. The eye, or any detector, is not capable of distinguishing relative light intensities below a certain limiting value called the contrast threshold. Given two light intensities I_1 and I_2 ($I_1 < I_2$), there exists a number ε such that if

$$1 - \frac{I_1}{I_2} < \varepsilon \quad (2)$$

the eye is incapable of distinguishing between the two intensities.

Thus, if the object is moved toward the horizon (away from the observer) it will eventually arrive at a point v such that

$$1 - \frac{I_v}{I_\infty} = \varepsilon \quad \text{.......... (3)}$$

Beyond that point the object is no longer visible to the eye. Using (3) in (1), one obtains

$$\varepsilon = (1 - I_o/I_\infty) \exp(-kv)$$

or

$$vk = \ln \frac{1}{\varepsilon} (1 - I_o/I_\infty) \quad \text{.......... (4)}$$

A value for k can be obtained by measuring the contrast between the object and the horizon. From equation (1)

$$kx = \ln \left[\frac{1 - I_o/I_\infty}{1 - I_x/I_\infty} \right] \quad \text{.......... (5)}$$

Consequently, combining (4) and (5)

$$v = x \frac{\ln \frac{1}{\varepsilon} (1 - I_o/I_\infty)}{\ln (1 - I_o/I_\infty) - \ln (1 - I_x/I_\infty)} \quad \text{.......... (6)}$$

The distance v is what has been termed the visual range, denoted by VR in this report.

If the object is black, $I_o = 0$, then (6) takes on a more simple form:

$$VR = \frac{x \ln \varepsilon}{\ln (1 - I_x/I_\infty)} \quad \text{.......... (7)}$$

Fortunately it is not necessary to employ truly black objects. For many objects the reflectance is such that I_o/I_∞ is very small. Objects which fit into this category are foliage, open windows, and other objects which are dark. By an argument not reproduced here (Steffans 1949), it may be deduced that

$$I_o/I_\infty = A_o/2, \text{ (i.e., } I_i = 0.5\, I_\infty) \quad \ldots\ldots(8)$$

For example, consider dry rough earth which has a reflectance of approximately 0.25. The error in visual range caused by assuming $I_o = 0$ is approximately 10 percent, based on the difference in visual ranges obtained assuming no reflectance and a reflectance of 0.25.

The selection of reflectance values was made according to the discussion in Section A.7.1.3.3.

A.7.4.2 Photometry

In the linear portion of the characteristic curve, that portion of the curve in which the image densities fell during this study (Figure A-15), the images on a photographic negative have relative densities D which may be expressed by

$$D = g + \gamma \ln E \quad \ldots\ldots(9)$$

where E is the exposure and g and γ are constants relative to a given film. The constant g is irrelevant, and γ can be obtained by sensitometry. Once γ and the necessary relative densities are known, the relative intensities may be calculated. For example, consider two images 1 and 2 on a negative of known γ. Then

$$D_1 - D_2 = \gamma \ln (I_1/I_2)$$

or

$$I_1/I_2 = \exp \left[(D_1 - D_2)/\gamma \right] \quad \ldots\ldots(10)$$

In applying (10) to the calculation of visual range, I_1 is associated with the image density of the object, and I_2 is associated with the image density of the horizon.

If the image densities do not fall in the linear portion of the curve, I_1/I_2 can be obtained as explained in the text. In this investigation, all densities lay in the linear portion of the curve.

In equation (10) let D_1 and D_2 be associated with D_x and D_∞, respectively. Then

$$k = \frac{\ln \{\frac{1}{\Theta}(1 - I_0/I_\infty)\}}{x} \quad \ldots\ldots (11)$$

where

$$\Theta = 1 - \exp\left[(D_x - D_\infty)/\gamma\right].$$

Thus, it is easily possible for the system consisting of camera, film and, densitometer to penetrate haze to a greater extent than the eye. The instrumental system does not lead to an over-estimate in visual range. The fundamental quantity measured by camera, film, and densitometer is the extinction coefficient k. From the latter, visual range is determined from

$$V = \frac{M}{k} \quad \ldots\ldots (12)$$

where

$$M = \ln\frac{1}{\varepsilon}(1 - I_0/I_\infty)$$

Applying equation (8) to equation (12) and including a correction constant to convert base 10 log to natural log results in:

$$\text{VISUAL RANGE} = \frac{x \ln\frac{1}{\varepsilon}(1 - \frac{A}{2})}{\ln\left[\dfrac{(1-\frac{A}{2})}{1 - e^{\{(2.302585)(D_x - D_\infty)/\gamma\}}}\right]} \quad \ldots\ldots (13)$$

An example of a visual range calculation follows:

$$VR = \frac{x \ln \frac{1}{\varepsilon} (1 - \frac{A}{2})}{\ln \left[\frac{(1 - \frac{A}{2})}{1 - e^{\{(2.302585)(D_X - D_\infty)/\gamma\}}} \right]}$$

where

x = 54 miles	Date:	June 6, 1976
ε = 0.02	Time:	0830 MST
A = 0.15	Object No.:	1
D_X = 0.74		
D_∞ = 0.75		
γ = 0.87		

$$VR = \frac{54 \ln \frac{1}{0.02} \left[1 - \frac{0.15}{2}\right]}{\ln \left[\frac{(1 - \frac{0.15}{2})}{1-e^{\{(2.302585)(0.74-0.75)/0.87\}}} \right]}$$

$$VR = \frac{207.04}{3.57}$$

$$VR = 58.0 \text{ miles}$$

A.8 Noise

A.8.1 Methodology

The noise program consisted of two parts: 1) a one-time estimate, corresponding to peak-hour traffic on a typical day in 1974 of traffic noise levels in the Piceance Basin and 2) short-term noise level measurements for the period from September 1975 through October 1976 in the vicinity of the C-b Tract.

Peak hour traffic estimates at the 13 sampling locations shown on Figure 2-5 were supplied by the Colorado State Highway Department. That agency also supplied a nomograph entitled, "Nomograph for Approximate Prediction of Highway Noise Levels" and data from their computer program DFINCLS.

Noise level measurements using a sound level meter were made at the 14 locations shown on Figure 2-4. Meter specifications are presented in Table A-13. This General Radio type 1565-B Sound Level Meter and 1562-A Sound Level Calibration are illustrated on Figure A-16.

A.8.1.1 Sampling Techniques, Frequency, and Format

In conjunction with using the sound level meter a windscreen was used for all the outdoor measurements and no measurements were made with wind speeds greater than 30 mph. The microphone was pointed at right angles to the direction of the estimated noise path as indicated in Figure A-17.

In one complete set of measurements the following procedure was used:

For the two locations along Piceance Creek road:

(1) A weighting, fast meter response was used to measure peak noise level for five passing vehicles.

(2) The type and condition of vehicle and distance from the center line of lane of travel for each vehicle was recorded.

(3) Background noise (no traffic) at each location using A, B, and C weighting was recorded.

Table A-13

SOUND-LEVEL METER (SLM) SPECIFICATIONS

Type:	General Radio Type 1565-B
Sound Level:	40 to 140 dB
Weighting:	A, B, & C. Conforms to ANSI S1.4-1971 Type 2 and IEC 123, 1961.
Meter:	RMS response with fast and slow speeds.
Input:	Microphone: Lead-zircornate-titanate ceramic. Input impedance ≈ 13 MΩ/15pF
Output:	1.2V rms behind 620 Ω with meter at full scale. Harmonic distortion; ≤ 0.5% from 32 Hz to 8kHz, C-weighted with meter at full scale.
Calibration:	Can be pressure calibrated at 125, 250, 500, 1000, 2,000 Hz with 1562 Sound-Level Calibrator.
Environmental:	Temperature - -10 to 50^{o}C operating Humidity: 90% Magnetic Field - 1 Oersted (80 A/m) 50 or 60 -Hz field causes ≈ 45 dB C-weighted indication.
Power:	Two 9V batteries
Weight:	13 oz. net.
Calibrator:	Type 1562-A Sound Level Calibrator 125 to 2000 Hz ±0.3 dB accuracy at 500 Hz ±0.5 dB at other frequencies

SOUND-LEVEL MEASUREMENT SET CONSISTING OF THE GENERAL RADIO SOUND LEVEL METER 1565-B AND SOUND LEVEL CALIBRATOR 1562-A
FIGURE A-16

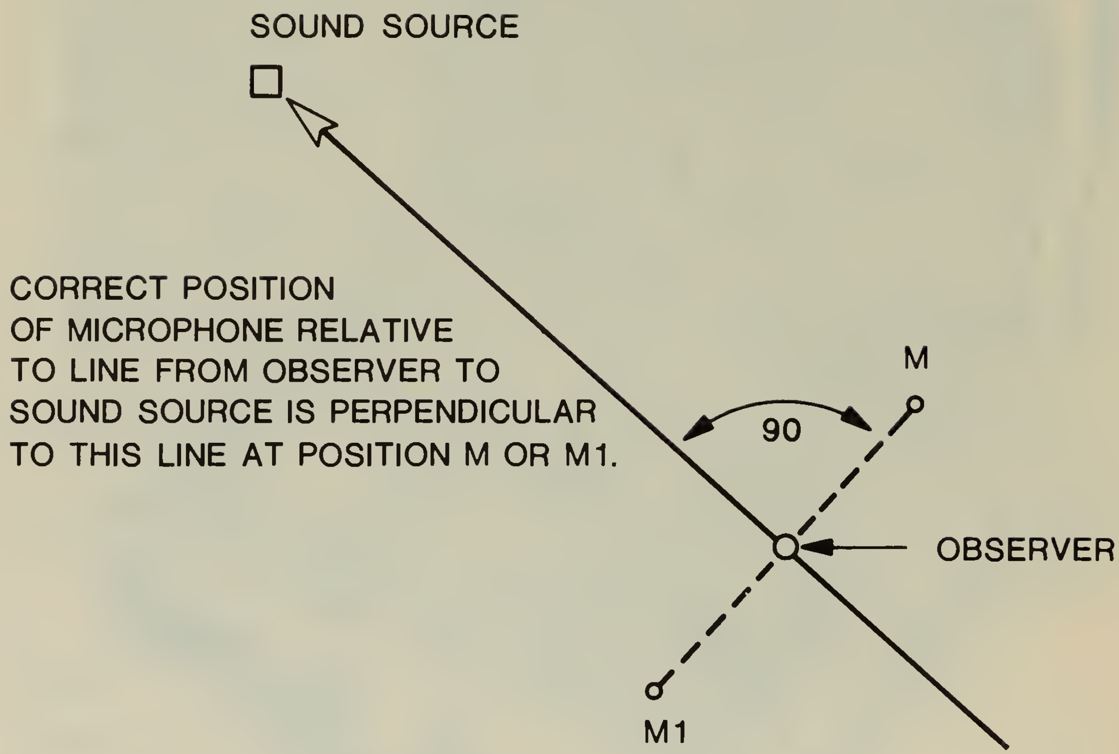


FIGURE A-17

OBSERVER-SOURCE-MICROPHONE GEOMETRY

All other locations:

(4) A, B, and C weighting, slow response was used to record noise levels.

(5) At locations at intervals away from mine and plant site, the meteorological tower was used to orient the meter, i.e., the meteorological tower was assumed to be the noise source.

(6) At locations at the Tract boundaries, the meter was oriented to measure noise emitted from on-Tract.

This sampling procedure was followed one day per month for 13 months starting in September 1975.

Note that the American National Standard Specification for sound-level meters (ANSI S1.4-1971) requires that three alternate frequency response characteristics be provided for instruments in general use. These responses are designated A, B, and C weightings and are shown in Figure A-18 and have been utilized in the above sampling procedure. Note that when all three readings are provided that an indication of the frequency distribution of the noise is given. For example, if all three give essentially the same answer then (by Figure A-18) the frequencies over 600 Hz predominate; if, on the other hand, the level is higher on C than B and B higher than A then the noise is probably lower than 600 Hz.

It should also be noted that OSHA requires readings at A weighting and slow meter response.

A.8.1.2 Reporting Frequency and Format

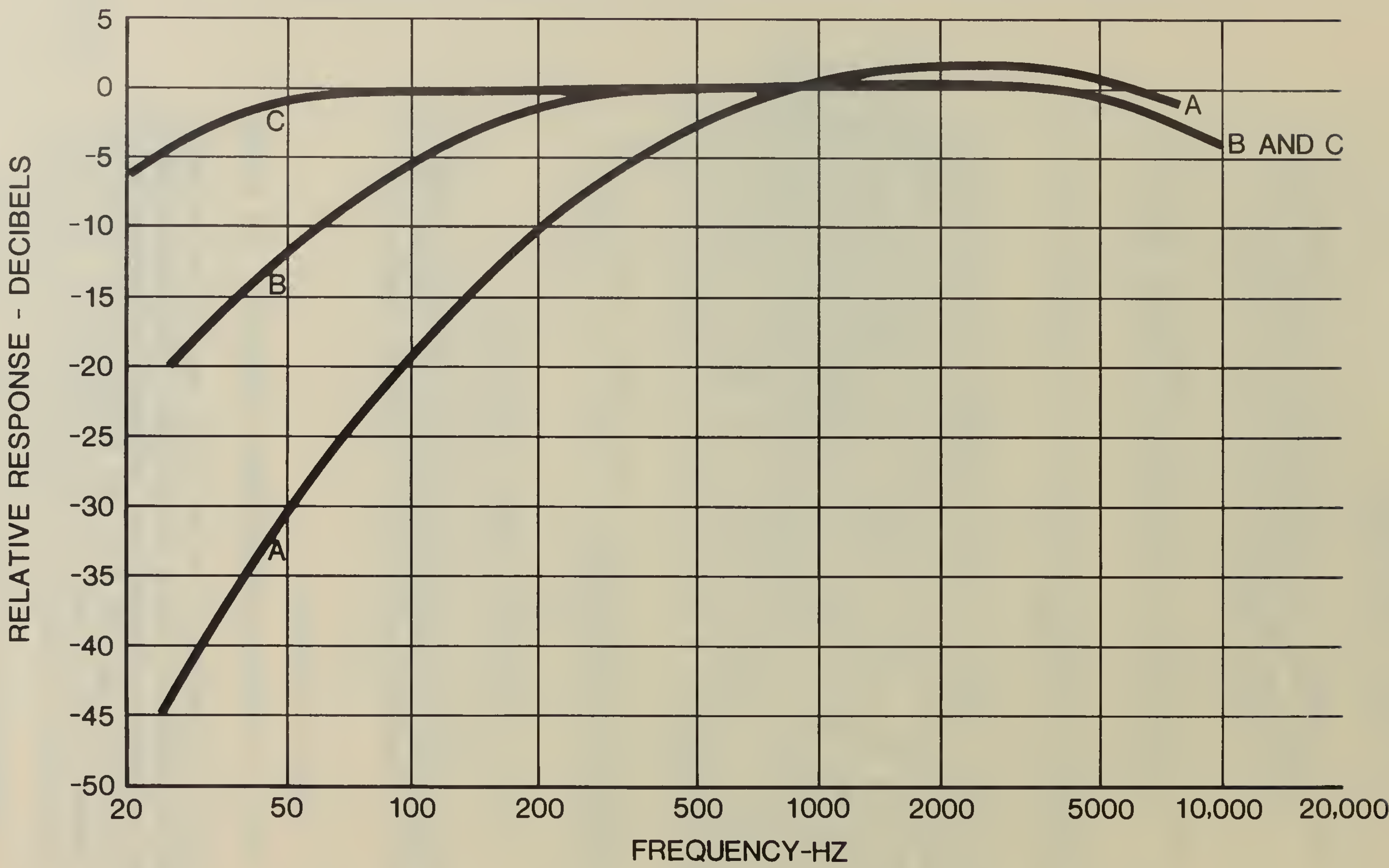
Reporting frequency is identical to the sampling frequency. A typical data sheet is presented on Table A-14 ; these data for each month have been presented in the quarterly data reports.

A.8.2 Quality Assurance

A.8.2.1 Calibration Technique, Frequency, and Format

The SLM is calibrated prior to taking each set of measurements with the companion 1562-A Sound Level Calibrator according to standard calibration procedure at calibration frequencies of 125, 250, 500, 1000, and 2800 Hz. The instrument is corrected for the altitude of the Support Facility Building at the C-b Tract by manufacturer-recommended techniques by adjusting the

FREQUENCY RESPONSES FOR SLM WEIGHTING CHARACTERISTICS



FREQUENCY-RESPONSE CHARACTERISTICS IN THE AMERICAN NATIONAL STANDARD SPECIFICATION FOR SOUND-LEVEL METERS, ANSI-S1.4-1971

FIGURE A-18

Table A-14

TYPICAL TRACT C-b NOISE STUDY DATA SHEET

Name: RW/CB

Date: 4-23-76

Met Tower Temperature (8'): $50^{O}F$

Wind Speed (8'): 8 mph at 11:25 a.m. MST

Location Number	Time (MST)	Meter Reading at Weighting: A	B	C	Response S	F	Position of Observer*	Microphone Noise **	Other (Vehicle Information)
	Background	50	51	59	✓				Cloudy and gusty winds
I. Collins Gulch 1.	0957	64				✓	Standing facing West: 6'		New Chevy Pkup 4WD
2.	1006	56				✓	Standing facing West: 6'		Datsun (New)
3.	1009	59				✓	Standing facing West: 6'		Dodge Trk, 4WD (New)
4.	1010	66				✓	Standing facing West: 6'		New Chevy Pkup Trk 4WD
5.	1014	52				✓	Standing facing West: 6'		Old Ford Pkup Trk
II. P. Creek E. of PL Gate	Background	49	54	62					
1.	1029	64				✓	Standing facing West: 6'		New Chevy Pkup Trk 4WD
2.	1031	68				✓	Standing facing West: 6'		New 1 Ton Trk Chevy
3.	1032	66				✓	Standing facing West: 6'		1976 Blazer 4WD
4.	1032	64				✓	Standing facing West: 6'		1969 Cadillac
III. SG-10	1424	49	56	81	✓				High SW winds
IV. SG-11	1136	46	55	68	✓				Cloudy and gusty winds
V. SG-9	1455	51	61	78	✓				
VI. C-b2b	1200	45	47	55	✓				
VII. AT-1	1154	51	62	69					
VIII. I. SE of AT-1 Conveyor	1157	46	47	57					
IX. Boundary (N)	1433	46	54	68					
X. SG-16 (S)	1132	47	52	68					Cloudy and gusty winds
XI. SG-8 (E)	1512	46	51	69					
XII. Willow Creek (W)	1443	49	60	72					
XIII. SG-1, Valley	1448	48	60	72					
XIV. SG-1 Ridge									

Meter Type: General Radio 1565-B Meter I.D. #: 28612
Microphone Serial No.: 44682

*Posture; direction facing; height of meter above ground level
**Should be perpendicular to noise path

instrument to read 112.8dB at 500 Hz instead of 114 dB indicated in the instruction manual. Design readings at all frequencies corrected for Tract altitude are:

Freq. (Hz)	125	250	500	1000	2000
Design Reading	114.25±1	113.6±1	112.8±1	112.3±1	112.0±2

A.8.2.2 Equipment Reliability

There have been no equipment reliability problems encountered.

APPENDIX B

Table B-1 presents conversion factors utilized in this report.

B.1 Meteorology

B.1.1 Wind Fields

The following figures and tables support subsection 3.1.1.5, Wind Fields:

Figure B-1a	C-b Terrain Elevations as a Function of Direction
Figure B-1b	C-b Terrain Elevations as a Function of Direction (cont'd)
	Wind Field Patterns for Nov. 1975
Figure B-2a	Total Days at 5 am MST
Figure B-2b	Total Days at 1 pm MST
Figure B-2c	Cloudy Days at 5 am MST
Figure B-2d	Cloudy Days at 1 pm MST

Note: "Clear" days patterns are Figures 3-3 and 3-4

Figure B-3	Station 021 30' Elevation Wind Roses
Figure B-4	Station 023 30' Elevation Wind Roses
Table B-2	Meteorological Summary: Wind Speed and Direction
	Gust Analysis - Number of 5-Min. Samples
Table B-3a	30-Ft. level
Table B-3b	100-Ft. level
Table B-3c	200-Ft. level

Wind Persistence at Specified Stability

Table B-4a	Stability A	
Table B-4b	Stability B	
Table B-4c	Stability C	Note: F Stability is Table 3-2
Table B-4d	Stability D	
Table B-4e	Stability E	

Table B-1

TABLE OF CONVERSION FACTORS

To Convert From	To	Multiply By
acres	ft^2	4.3560×10^4
atmospheres	newtons/m^2	1.01325×10^5
atmospheres	mm Hg	760
atmospheres	lbs/ft^2	2116.32
bars	newtons/m^2	10^5
bars	atmospheres	0.98692
BTU (British Thermal Units)	gm. cal.	252.
degrees Fahrenheit	degrees Kelvin	$(^oF-32)(5/9) + 273$
degrees Fahrenheit	degrees Centigrade	$(^oF-32)(5/9)$
feet	meters	0.3048
$feet^3$ per min.	cubic meters per sec.	0.000427
grains	grams	0.064798918
grains	pounds	1.42857×10^{-4}
hectares	$meters^2$	10^4
miles	kilometers	1.609
miles per hour	meters per second	0.44703
pounds	kilograms	0.45359
pounds per hour	grams per second	0.1260
pounds per in^2	millibars	68.947
pounds per in^2	atmospheres	0.068046
SCFM (standard cubic ft./min.)	ACFM (actual cubic ft./min.)	$(^oK_A/^oK_S)(P_Smb/P_Amb)$

Multiples and Submultiples of Units

Factor by which unit is multiplied	Prefix	Symbol
10^{12}	tera	T
10^9	giga	G
10^6	mega	M
10^3	kilo	k
10^2	hecto	h
10	deka	da
10^{-1}	deci	d
10^{-2}	centi	c
10^{-3}	milli	m
10^{-6}	micro	μ
10^{-9}	nano	n
10^{-12}	pico	p
10^{-15}	femto	f

POLLUTANT	TO CONVERT $\mu g/m^3$ AT 25° C AND 760 mmHg to ppb MULTIPLY BY
NO_x	.534
NO	.534
NO_2	.534
SO_2	.384
H_2S	.723
THC	1.536
CH_4	1.536
CO	.877
O_3	.512

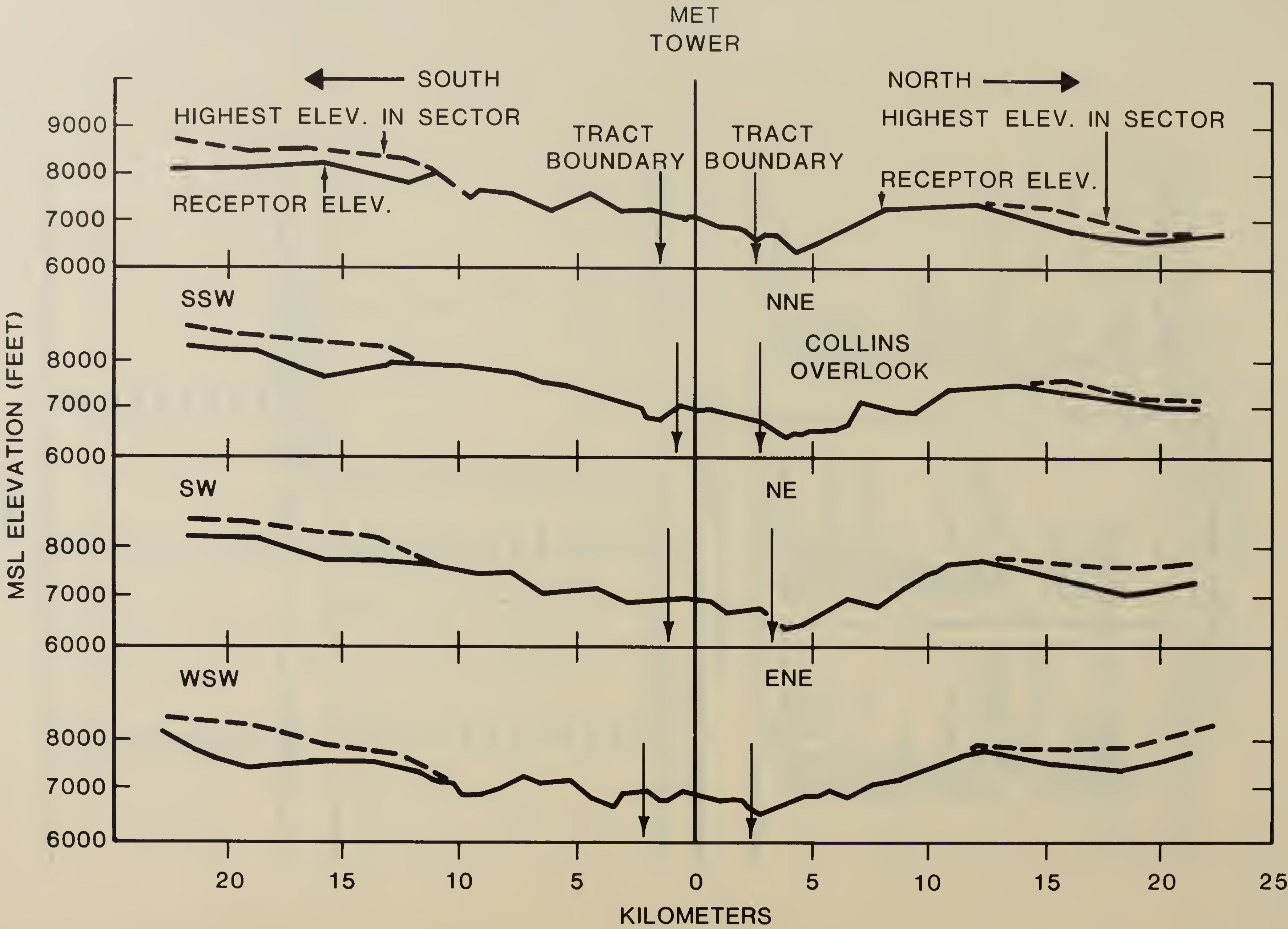


FIGURE B-1a C-b TERRAIN ELEVATIONS AS A FUNCTION OF DIRECTION

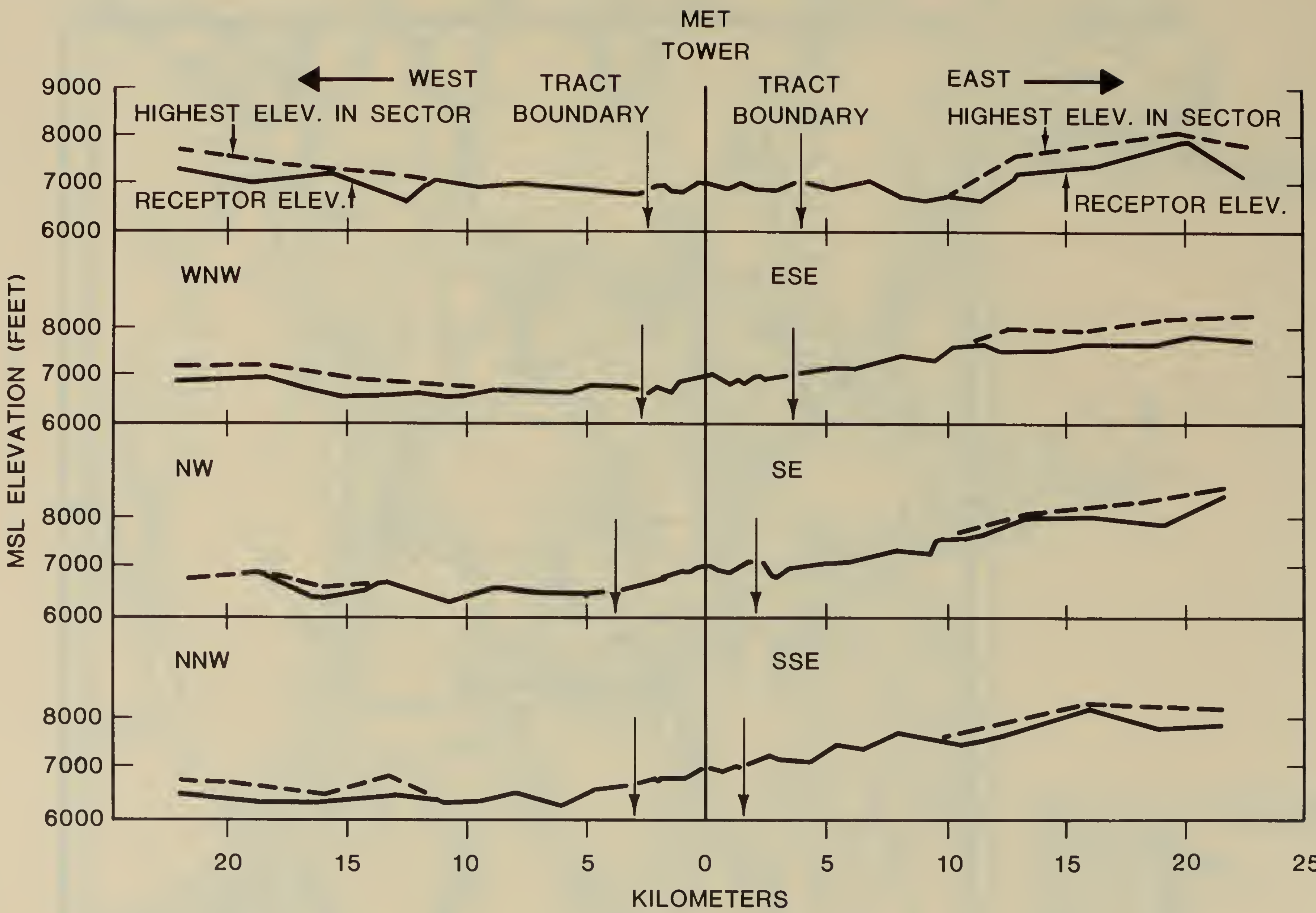
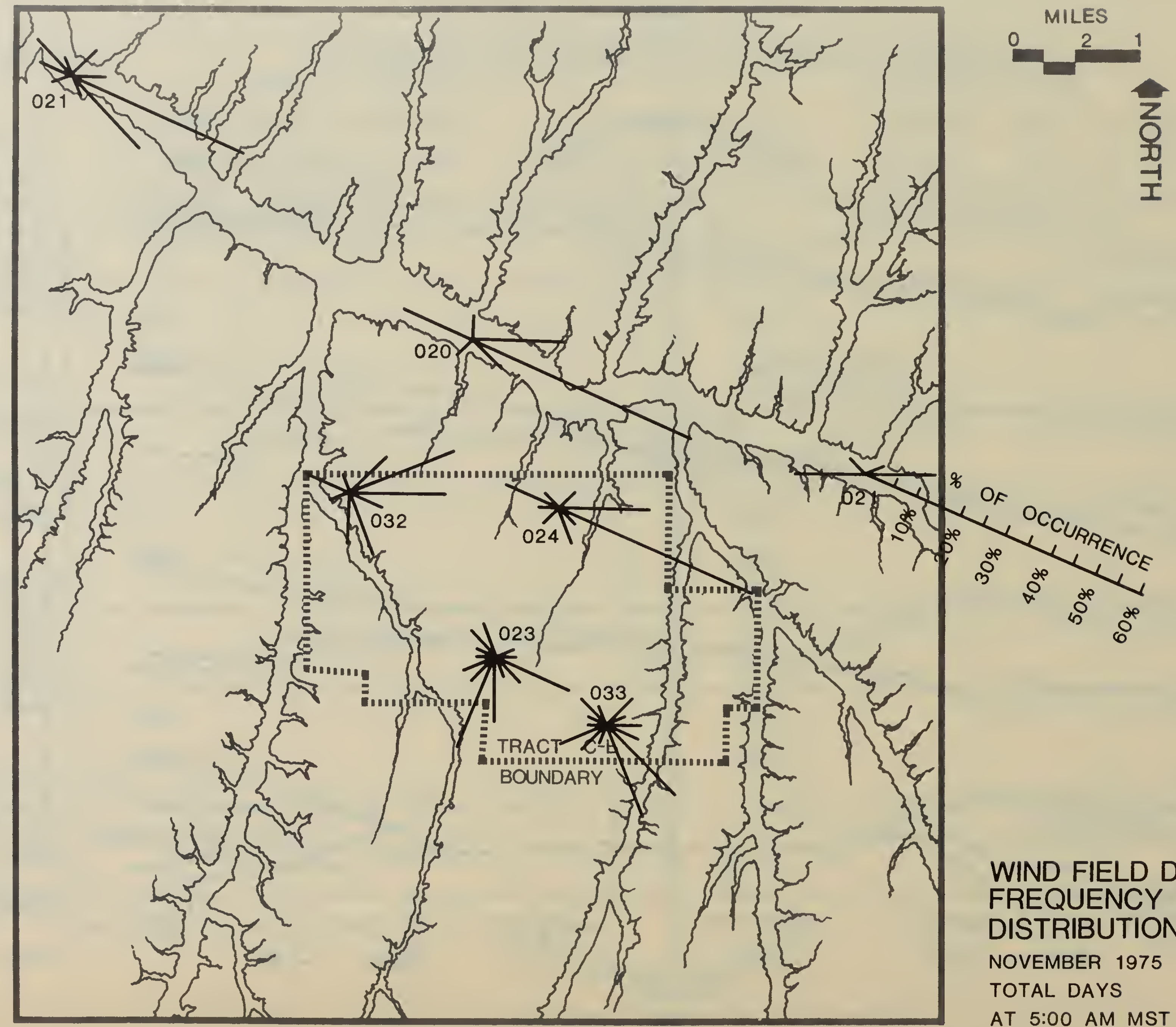
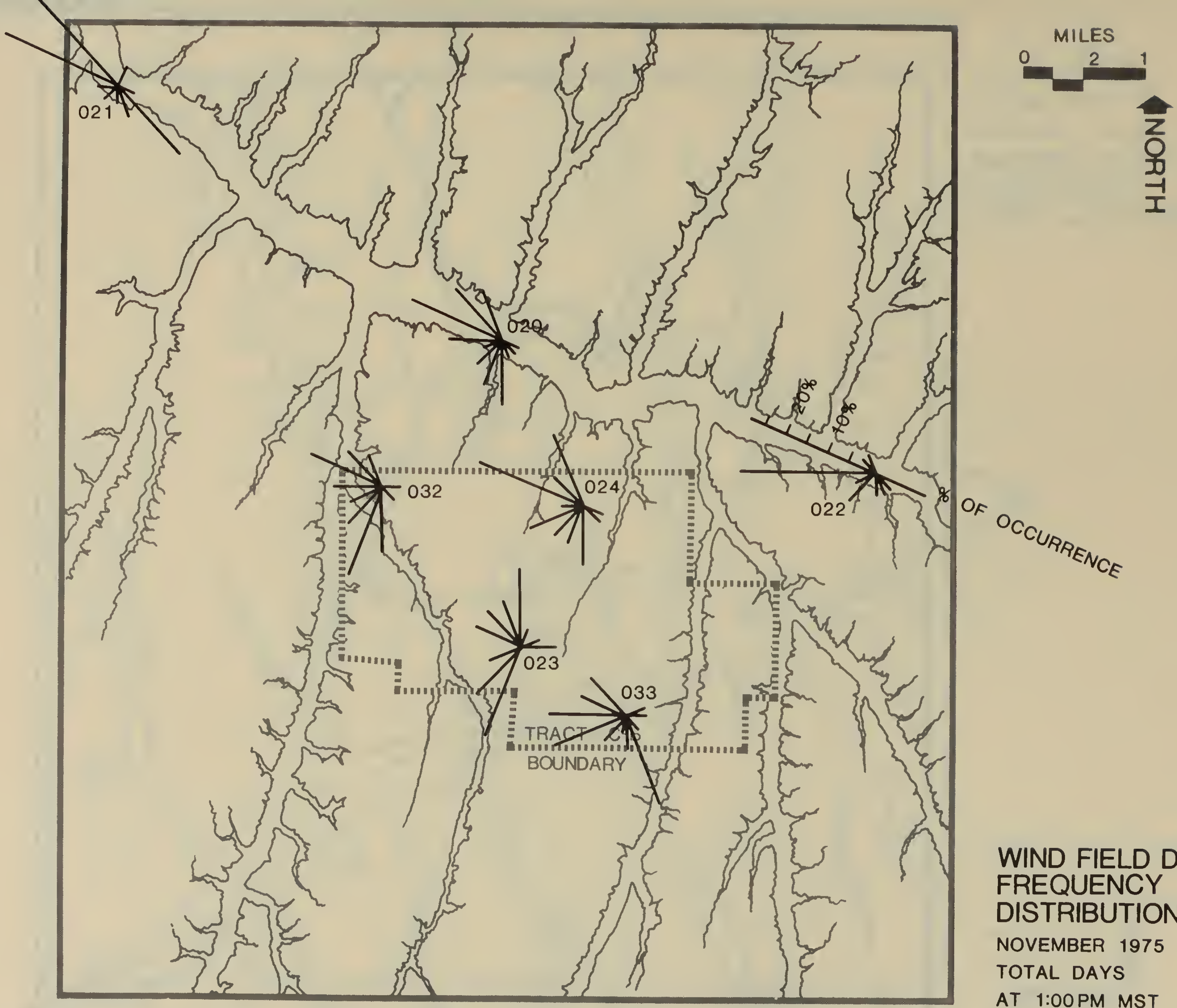


FIGURE B-1b C-bTERRAIN ELEVATIONS AS A FUNCTION OF DIRECTION



WIND FIELD DIRECTION FREQUENCY DISTRIBUTIONS
NOVEMBER 1975
TOTAL DAYS
AT 5:00 AM MST

FIGURE B-2a



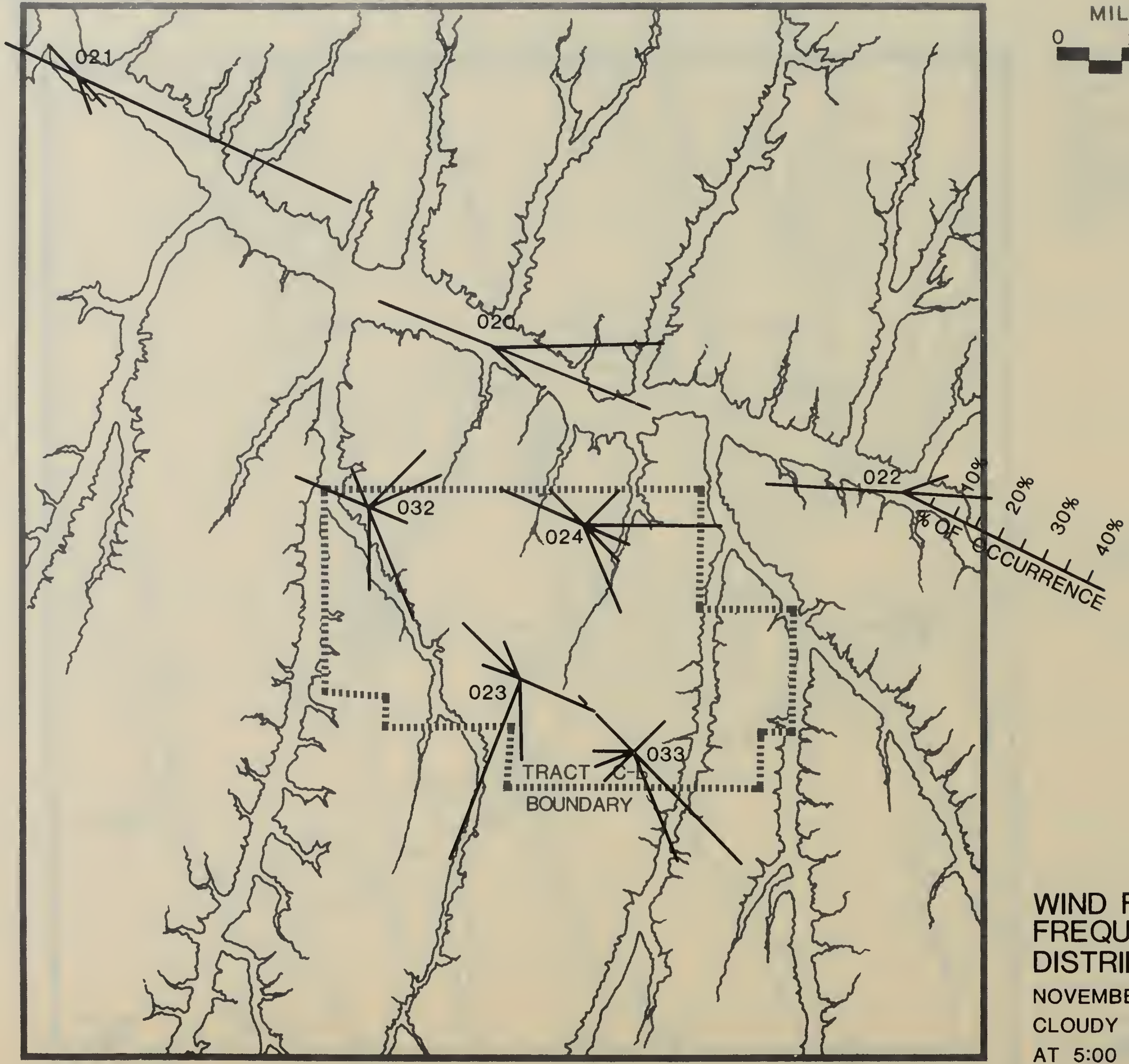
WIND FIELD DIRECTION FREQUENCY DISTRIBUTIONS

NOVEMBER 1975

TOTAL DAYS

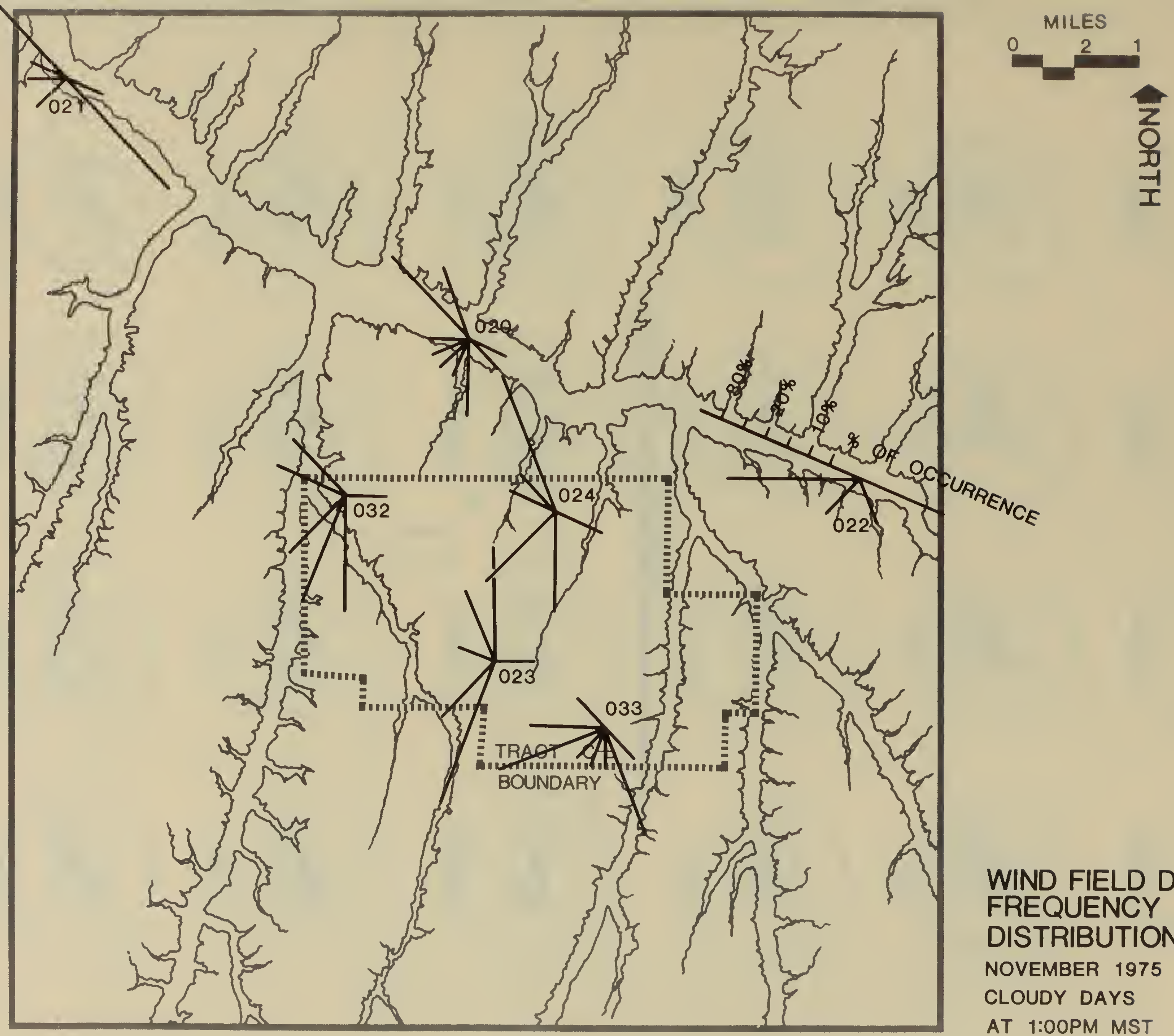
AT 1:00PM MST

FIGURE B-2b



WIND FIELD DIRECTION FREQUENCY DISTRIBUTIONS
NOVEMBER 1975
CLOUDY DAYS
AT 5:00 AM MST

FIGURE B-2c



WIND FIELD DIRECTION FREQUENCY DISTRIBUTIONS
NOVEMBER 1975
CLOUDY DAYS
AT 1:00PM MST

FIGURE B-2d

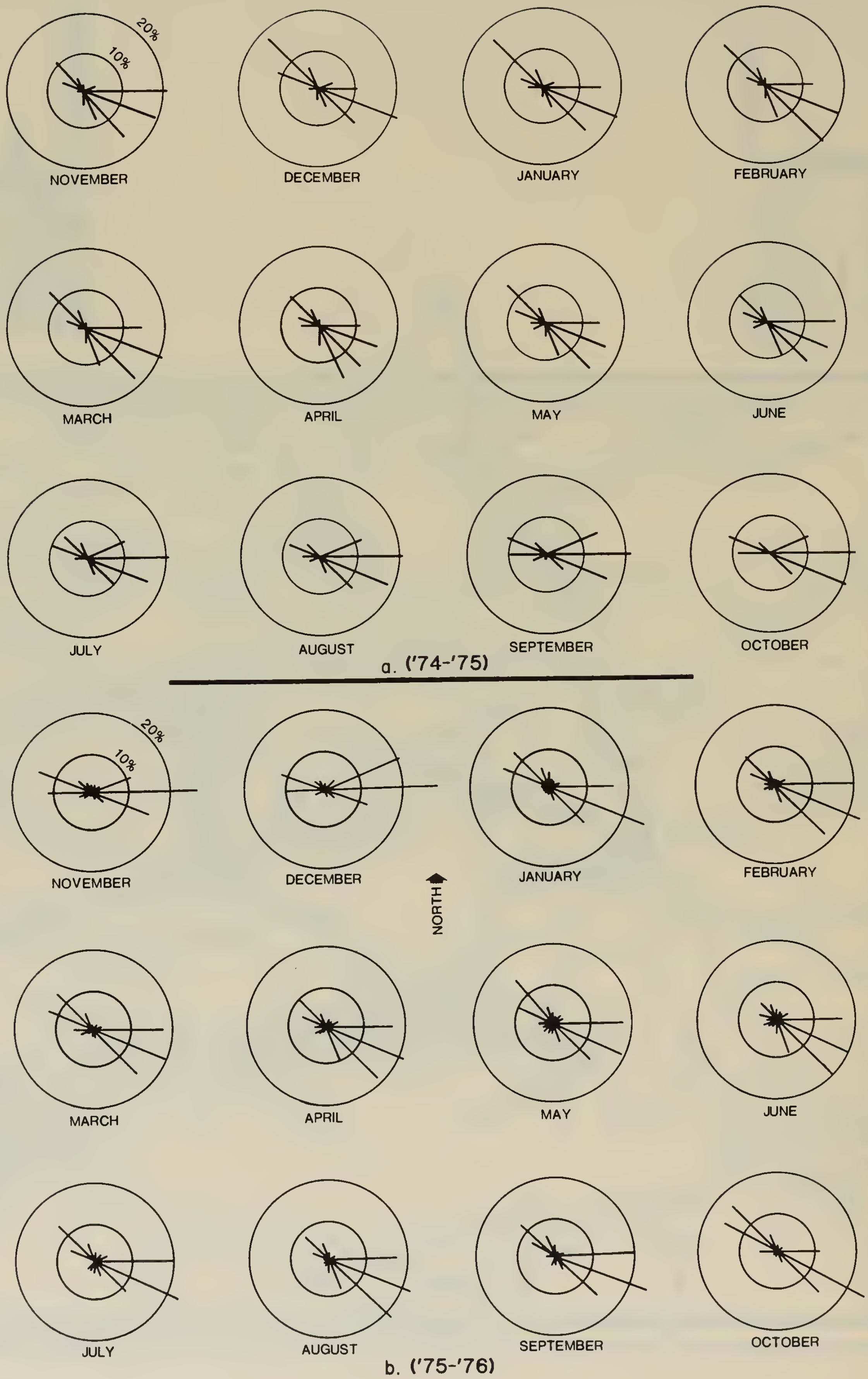


FIGURE B-3 STATION 021 30′ ELEVATION WIND ROSES

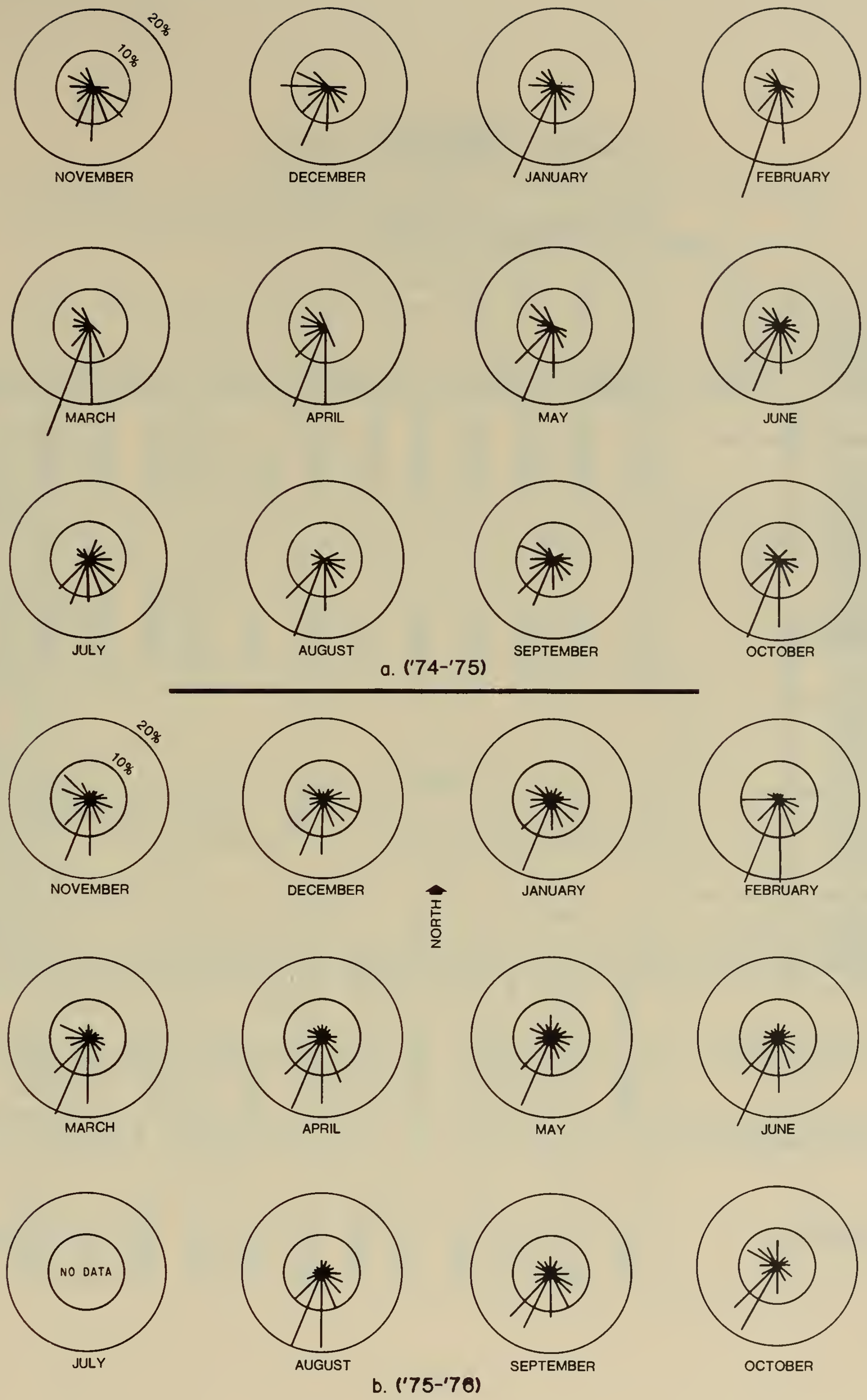


FIGURE B-4 STATION 023 30' ELEVATION WIND ROSES

Table B-2
METEOROLOGICAL SUMMARY: WIND SPEED AND DIRECTION
(30 foot Height)
1974-1975

TRAILER	ITEM	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	ANNUAL
Tower 200'	Wind Speed, 5-Min. Max. (MPH)	39	52	48	36	52	56	53	52	42	41	36	49	
	& Associated Direction (Deg.)	203	239	205	209	193	178	179	228	188	229	244	209	
020	Wind Speed, Hourly Max. (MPH)	11	11	18	18	17	24	(1)	(1)	(1)	17	20	18	
021		19	13	19	17	20	28	21	20	16	18	16	21	
022		15	20	18	17	19	17	15	17	15	17	19	15	
023		25	38	32	24	38	43	38	28	25	22	21	33	
024		19	25	25	20	33	37	31	25	21	21	23	31	
020	& Associated Direction (Deg.)	129	129	288	293	118	155	(1)	(1)	(1)	301	295	158	
021		340	344	347	345	168	162	165	312	296	275	268	135	
022		105	270	285	285	110	126	131	286	107	287	283	118	
023		200	246	198	193	189	175	170	213	178	216	273	189	
024		177	162	197	230	155	172	183	212	111	303	277	175	
020	Wind Speed, Hourly Avg. (MPH)	3	3	5	5	5	6	6	(1)	4	5	5	5	5
021		3	4	6	6	6	6	6	6	4	5	5	5	5
022		5	5	6	6	6	6	6	6	5	6	6	6	6
023		7	7	8	8	10	10	9	8	7	8	6	8	8
024		3	3	5	5	7	7	7	7	5	6	5	7	6
020	Wind Direction, Hourly Avg. (Deg.)	114	102	115	126	131	137	137	121	106	124	105	126	120
021		124	95	119	143	142	156	141	136	113	126	107	113	126
022		105	106	104	111	105	116	106	85	94	114	94	120	105
023		197	232	202	200	202	118	217	199	164	188	216	190	202
024		95	96	129	108	153	191	186	162	109	136	82	150	133

1975-1976

TRAILER	ITEM	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	ANNUAL
Tower 200'	Wind Speed, 5-Min. Max. (MPH)	39	37	35	57	44	43	40	44	41	51	37	39	
	& Associated Direction (Deg.)	308	200	198	217	187	248	254	166	208	184	195	240	
020	Wind Speed, Hourly Max. (MPH)	16	14	13	23	26	23	(1)	(1)	(1)	19	13	15	
021		20	17	14	20	22	25	18	22	15	21	15	16	
022		16	18	15	21	27	21	15(2)	15(2)	15	17	12	12(2)	
023		33	25	27	32	28	25	23(2)	27	22	36	20	22	
024		28	21	21	29	35	25	17(2)	21	15	31	17	21	
020	& Associated Direction (Deg.)	147	104	140	304	292	154	(1)	(1)	(1)	133	93	341	
021		316	98	126	312	266	132	283(2)	321	99	132	130	322	
022		114	281	116	286	279	112	285(2)	122(2)	129	132	117	129(2)	
023		176	192	202	188	190	179	195	219	217	179	222	225	
024		188	183	187	208	275	178	261	225	232	170	229	230	
020	Wind Speed, Hourly Avg. (MPH)	5	5	5	6	5	5	5(2)	(1)	4(2)	6	4	5	5.0
021		5	5	5	6	6	6	5	7	5	6	5	5	4.9
022		6	6	6	6	6	5	5	6(2)	5	5	4	5(2)	5.4
023		7	6	5	9	6	8	7	9	6	9	6	5	6.9
024		6	5	4	8	8	8	6	8	5	7	5	4	6.2
020	Wind Direction Hourly Avg. (Deg.)	117	112	110	132	127	118	102	126	87	110	92	86	110
021		100	88	80	104	109	117	100	121	92	114	101	101	102
022		119	110	106	112	109	106	90	129(2)	107	119	111	113(2)	111
023		205	173	195	190	213	203	201	189	170	175	191	225	194
024		144	116	121	146	155	157	128	162	117	143	116	85	132

(1) Missing Data

(2) Partial Data

Table B-3

GUST ANALYSIS - NO. OF 5-MIN. SAMPLES

a. 30 Ft. Level

WIND SPEED RANGE (MPH) (WS_1-WS_2)

Month	36-40	41-45	46-50	51-55	56-60	61-65	Tot. No. of 5-Min. Samples
Nov. '74							*
Dec. '74		1					*
Jan. '75	1						6712
Feb. '75							6368
Mar. '75	1	1					5628
Apr. '75			1				7884
May '75	1	1					8034
June '75		1					6896
July '75							7682
Aug. '75							7715
Sept.'75							7270
Oct. '75	2						8143
Nov. '75	2						7894
Dec. '75							7681
Jan. '76							7884
Feb. '76	1	1					7757
Mar. '76	1						7778
Apr. '76							6574
May '76							7059
June '76							7760
July '76							*
Aug. '76	1						7636
Sept.'76							7378
Oct. '76							7369
Total	10	5	1	0	0	0	139,537
Expectation	0.7167×10^{-4}	0.3583×10^{-4}	$.0717 \times 10^{-4}$	0.0	0.0	0.0	
P(exceeding WS_2)	0.430×10^{-4}	0.0717×10^{-4}	0.0	0.0	0.0	0.0	

* Missing Data

Table B-3

GUST ANALYSIS - NO. OF 5-MIN. SAMPLES

b. 100 Ft. Level

WIND SPEED RANGE (MPH)(WS_1-WS_2)

Month	36-40	41-45	46-50	51-55	56-60	61-65	Tot. No. of 5-Min. Samples
Nov. '74							8291
Dec. '74	1		1				4826
Jan. '75	1	1					7013
Feb. '75							6345
Mar. '75	1		1				5641
Apr. '75	2			1			7882
May '75		1	1				7977
June '75	1		1				6840
July '75	1	1					7665
Aug. '75	2						7678
Sept.'75							7175
Oct. '75	4	2					7947
Nov. '75	1	2					7788
Dec. '75							7544
Jan. '76							7422
Feb. '76	2	1		1			7655
Mar. '76	3	1					7797
Apr. '76	3						6548
May '76	1						6983
June '76	4						7759
July '76							*
Aug. '76	1	2					7604
Sept.'76							7187
Oct. '76	1						7140
TOTAL	29	11	4	2	0	0	166,707
Expectation	1.7396×10^{-4}	0.6598×10^{-4}	0.2399×10^{-4}	0.12×10^{-4}	0.0	0.0	
P(exceeding WS_2)	1.0197×10^{-4}	0.3599×10^{-4}	0.12×10^{-4}	0.0	0.0	0.0	

* Missing Data

Table B-3

GUST ANALYSIS - NO. OF 5-MIN. SAMPLES

c. 200 Ft. Level

WIND SPEED RANGE (MPH) (WS_1-WS_2)

Month	36-40	41-45	46-50	51-55	56-60	61-65	Tot. No. of 5-Min. Samples
Nov. '74	1						8239
Dec. '74		1		1			5088
Jan. '75	2	1	1				7036
Feb. '75	2						6338
Mar. '75	1	1		1			5321
Apr. '75	2				1		7452
May '75	1		1	1			8102
June '75	3			1			6848
July '75	4	1					7619
Aug. '75	1	1					7694
Sept.'75	1						7203
Oct. '75	2	4	1				7932
Nov. '75	1	2					7791
Dec. '75	2						7191
Jan. '76							4376
Feb. '76	3	1	1		1		7811
Mar. '76	4	2					7754
Apr. '76	3	1					6729
May '76	1						6920
June '76	2	3					7773
July '76							*
Aug. '76	2	1		1			7549
Sept.'76	1						7129
Oct. '76	1						7113
Total	40	19	4	5	2	0	163,008
Expectation	2.4539×10^{-4}	1.1656×10^{-4}	0.2454×10^{-4}	0.3067×10^{-4}	0.1227×10^{-4}	0.0	
P(exceeding WS_2)	1.8404×10^{-4}	0.6748×10^{-4}	0.4294×10^{-4}	0.1227×10^{-4}	0.0	0.0	

* Missing Data

Table B-4 WIND PERSISTENCE AT SPECIFIED STABILITY
November 1974 - October 1976

a. Stability A

Direction	Max. Duration Hrs. / Date				
N	2 / 6-5-75				
NNE	4 / 12-24-75	3 / 1-11-75	3 / 7-18-76	3 / 8-27-76	
NE	2 / 12-8-75	2 / 4-3-76	2 / 10-1-76		
ENE	2 / 9-8-75	2 / 5-23-76	2 / 7-13-76		
E	2 / 11-15-75	2 / 7-24-76			
ESE	2 / 1-12-75	2 / 12-17-75	2 / 7-23-76	2 / 8-25-76	
SE	4 / 5/6-5/7-76	2 / 5-21-75	2 / 8-3-75		
SSE	3 / 5-5-75				
S	---- / ---				
SSW	2 / 12-5-75	2 / 5-8-76			
SW	3 / 5-8-76	2 / 9-20-76			
WSW	2 / 8-1-76				
W	4 / 2-5-76	3 / 4-12-75	3 / 2-6-76		
WNW	6 / 10-27-75	5 / 3-29-76	5 / 9-26-76		
NW	4 / 10-24-75	4 / 3-7-76	3 / 1-28-76		
NNW	3 / 11-8-75	2 / 1-10-75	2 / 5-2-75	2 / 11-4-75	2 / 10-8-76

Table B-4 WIND PERSISTENCE AT SPECIFIED STABILITY
November 1974 - October 1976

b. Stability B

Direction	Max. Duration Hrs. / Date		
N	4 / 8-4-76	4 / 9-28-76	3 / 8-9-75
NNE	3 / 9-27-75	3 / 10-17-75	2 / 4-30-76
NE	4 / 7-22-76	2 / 5-14-75	2 / 6-10-75; 2 / 6-11-75
ENE	2 / 8-20-75	2 / 10-25-75	
E	4 / 7-31-76	1 / 5 times	
ESE	2 / 5-21-75	2 / 9-9-75	
SE	2 / 5-5-75		
SSE	3 / 12-6-75	2 / 5-5-75	2 / 10-26-75
S	6 / 3-31-76	5 / 12-4-75	4 / 11-27-75
SSW	6 / 2-11-76	5 / 8-5-75	5 / 3-16-76
SW	7 / 10-18-75	5 / 1-18-76	4 / 5-17-75; 4 / 9-6-75
WSW	4 / 6-11-75	3 / 4-23-76	2 / 4-24-76
W	4 / 4-27-75	4 / 4-29-75	3 / 6-24-76
WNW	7 / 5-2-75	5 / 5-28-75	4 / 3-30-76
NW	7 / 12-14-75	5 / 10-31-75	5 / 5-2-76
NNW	6 / 5-31-75	5 / 5-13-75	5 / 1-25-76

Table B-4 WIND PERSISTENCE AT SPECIFIED STABILITY
November 1974 - October 1976

c. Stability C

Direction	Max. Duration Hrs. / Date			
N	3 / 4-30-76	3 / 9-26-76	2 / 8-31-76	
NNE	2 / 9-30-75			
NE	2 / 6-16-76			
ENE	-- /			
E	-- /			
ESE	-- /			
SE	-- /			
SSE	2 / 4-25-76	2 / 7-19-76		
S	2 / 3-11-76			
SSW	4 / 3-18-75	4 / 5-15-75	4 / 3-13-76	4 / 12/15-12/16-75
SW	3 / 4-9-75	3 / 5-18-76	3 / 6-12-76	
WSW	2 / 8-23-76			
W	2 / 6-24-76			
WNW	3 / 1-1-76	2 / 4-11-75	2 / 11-29-75	
NW	8 / 10-23-75	4 / 11/18-11/19-75	2 / 5-15-76	
NNW	3 / 5-29-75	2 / 11-19-75	2 / 3-25-76	

Table B-4 WIND PERSISTENCE AT SPECIFIED STABILITY
November 1974 - October 1976

d. Stability D

Direction	Max. Duration Hrs.	Date	Hrs.	Date	Hrs.	Date	Hrs.	Date
N	6	4-30-76	3	6-3-75				
NNE	4	4-26-75						
NE	--	--						
ENE	--	--						
E	2	8-21-75	2	10-14-75				
ESE	2	7-20-76						
SE	5	7-23-76	2	3-23-75	2	7-9-76		
SSE	4	3-25-75	4	10-10-75	2	7-19-76		
S	14	5-4-75	12	4-25-75	11	3-25-75	11	10-11-75
SSW	27	2-7-75	25	10-26-75	15	3-21-75	15	12-1-75
SW	10	4-22-75	9	8-23-75	8	2/9-2/10-76		
WSW	5	4-9-76	3	4-18-75	3	5-15-75	3	11-6-75
W	4	1-25-75	4	2-15-75	4	5-16-75		
WNW	6	3-19-76	5	1-7-75	5	2-15-75	5	2-18-76
NW	6	1-8-75	4	4-25-75	4	11-19-76		
NNW	4	1-9-75	4	1-21-75				

Table B-4 WIND PERSISTENCE AT SPECIFIED STABILITY
November 1974 - October 1976

e. Stability E

Direction	Max. Duration Hrs. / Date			
N	2 / 1-27-75	2 / 9-20-75	2 / 9-30-75	
NNE	3 / 9-20-75	2 / 6-24-76		
NE	2 / 1-22-75			
ENE	2 / 9-11-75			
E	2 / 11-11-75	2 / 11-12-75	2 / 11-17-75	
ESE	3 / 8-9-76	3 / 9-18-76	3 / 6/29-6/30-76	
SE	4 / 8-27-75	4 / 9-10-75	3 / 7-11-76	
SSE	4 / 8-27-75	4 / 10-6-75	3 / 10-11-76	
S	4 / 4-15-75	4 / 4-24-75	4 / 10-11-75	4 / 8-7-76
SSW	7 / 2-11-75	7 / 5-23-75	6 / 2-16-75	6 / 9-1-75
SW	6 / 4-13-75	5 / 1-16-75	4 / 11-6-75	
WSW	3 / 7-15-75	2 / 3-23-75	2 / 4-10-76	
W	10 / 9/19-9/20-76	5 / 4-12-75	4 / 2-14-75	
WNW	8 / 2-14-75	2 / 3-24-76	2 / 3-24-76	
NW	4 / 2-14-75			
NNW	5 / 1-9-75			

The following detailed description supports the interstation wind field correlation study:

B.1.1.1 Interstation Wind Direction Correlations

Correlation and regression analyses were used to analytically establish the interstation correlations of wind direction for eight ground-level stations and the meteorological tower at the 100-foot level. Hourly values for wind direction for the month of November 1975 were used as input data to computer correlation programs. Output were tables and plots for multiple linear correlations and regressions and polynomial fits to the data. The nine station locations are identified in Figure 2-2. Data from the meteorological tower at an elevation of 100 feet (M100) were used with data from five instrumented trailers (020, 021, 022, 023, and 024) and three mechanical weather stations (021, 032, and 033) in these analyses.

Data used for the wind field correlation study were the November 1975 wind direction data reported for each of the stations. Definitions used to subdivide these data into subsets and methodology are included in Table B-5. Some data were deleted from total data because of missing data to obtain total common data used in most of the correlations. The data grouping definitions have been used throughout the study without further reference to the table. Definitions of DAY, NIGHT, CLEAR, and CLOUDY should be noted.

Four of the nine stations were located in Piceance Creek (020, 021, 022, 031) and five are located on the C-b Tract (M100, 023, 024, 032, 033). Stations M100 and 023 are both located on the meteorological tower with 023 being the 30-foot level and M100 being the 100-foot level. Data at all MRI stations are scaled from 7-foot to 30-foot level assuming the logarithmic profile described elsewhere in this report.

Before any analyses were performed, the direction data were screened by the computer to add or subtract 360^0 to all station data values with absolute differences greater than 180^0 from M100. Thus, if the meteorological tower indicated 350^0 and at the same hour a station indicated 10^0, the station value was changed to 370^0 so that correlations would truly reflect the 20^0 difference.

Because it was desirable that all comparisons be based on the same set of observations, the November 1975 data for all nine stations were edited to delete the set of observations that contained one or more missing observations. An observation set is a set of wind direction observations on a specified day and hour for all nine stations. After this deletion of data for missing observations, a total of 405 hours (about 17 days) remained for the total common data. Further groupings of the data are defined in

Table B-5

DEFINITIONS OF WINDFIELD CORRELATION METHODOLOGY AND DATA GROUPINGS

METHODOLOGIES	DATA GROUPINGS
1. Vector Directions - Resultant vectors for hourly wind direction by day and by hour of day for all stations.	1. Total Data - all data for each of 9 stations (M100, 020, 021, 022, 023, 024, 031, 032, 033) for hourly values of wind direction, and wind speed where applicable, except missing data.
2. Direction Differences - shortest arc difference in degrees between station M100 and other stations (M100 - STA). Positive difference is counter clockwise.	2. Missing Data - observations not recorded or not taken because of instrument failure.
3. Polynomial Fit - Least squares fit of polynomial. Only 1st, 2nd, and 4th degree fits were used.	3. Total Common Data - observation for all hours common to all stations. Missing data for any hour at any station deletes that hour from the Total data set. A total of 405 hours remained from the 720 hours after deletions.
4. Paired Correlations - calculation of coefficient of correlation between independent observations of wind direction at two stations at same times.	4. DAY - hours from 1100 to 1700 inclusive. (118 hours)
5. Multiple Linear Regressions - the determination of the set of regression coefficients (bi) for a multivariable linear equation for estimating Y such as $\hat{Y} = b_o + b_1x_1 + b_2x_2 + b_3x_3 + \ldots\ldots$ The coefficients minimize the sum of differences between observed Y and estimated $\hat{Y}$ (called residuals).	5. NIGHT - hours from 2100 to 0700 inclusive. (191 hours)
6. Computer Digital Plots - scatter diagrams of observed values at one station plotted as a function of another observation or parameter by the computer. 1st, 2nd, or 4th degree polynomial fit curves are also plotted.	6. TRANS 1 - transition hours from night to day, 0800 to 1000 inclusive. (45 hours)
7. Calcomp Direction Plots - direction wind roses plotted by a Calcomp plotter.	7. TRANS 2 - transition hours from day to night, 1800 to 2000 inclusive. (51 hours)
8. Hand Drawn Graphs - graphs of functions plotted by hand.	8. DAY CLEAR - that subset of DAY observations taken on clear days. (56 hours)
	9. DAY CLOUDY - that subset of DAY observations taken on cloudy days. Cloudiness based on 2 PM solar radiation where full sunlight is 36 Langleys. Solar radiation $\geq$22 Langleys classified as clear, otherwise cloudy. (62 hours) There were 12 cloudy days (day 8, and days 18 thru 29 except 22).

Table B-5 (Cont'd)

9. RAMIS Plots - plots of wind direction plotted by the computer using RAMIS Data Base Management System Graph Capability.

10. Strip Charts - continuous plots of wind direction, wind speed, and temperature made by Meteorological Research, Inc., (MRI) mechanical weather stations.

10. NIGHT CLEAR - that subset of NIGHT observations taken on a clear night. Clear nights assumed to follow clear days. (92 hours)

11. NIGHT CLOUDY - that subset of NIGHT observations taken on a cloudy night. (97 hours)

Table B-5 as DAY, NIGHT, TRANS 1, TRANS 2, DAY CLEAR, DAY CLOUDY, NIGHT CLEAR, and NIGHT CLOUDY

A multiple-linear-regression computer program was used to compute coefficients of correlation between directions for Station M100 and the other eight stations. At the same time, coefficients of regression for a multiple-linear-regression equation were calculated. Other statistics were also computed. The results of these calculations are summarized in Table B-6. The tabulations are by divisions of the data as defined above for comparisons of Tract with Piceance Creek valley stations. Mean directions are given for each station. The standard deviation is given for the M100 tower station. The coefficient of correlation for each station relates to comparison of the station with M100. The intercept and slope are constants in the regression equation

$$Y = b_o + b_1 X$$

where Y = estimate of M100 direction based on the constants and an indicated station direction X. The standard deviation is for the regression line.

The conclusions of this study are presented in Section 3.1.1.5.1.

Table B-6

TRACT AND PICEANCE CREEK STATION CORRELATIONS WITH MET TOWER AT 100 FEET

a. Tract Stations

OBSERVATIONS		MET TOWER 100 Ft. Elevation		TRAILER 023					TRAILER 024					MRI 032					MRI 033				
Time	No.	Mean Deg.	Std. Dev. Deg.	Mean Dir. Deg.	Corr. Coeff.	Inter-cept Deg.	Slope	Std. Dev. Deg.	Mean Dir. Deg.	Corr. Coeff.	Inter-cept Deg.	Slope	Std. Dev. Deg.	Mean Dir. Deg.	Corr. Coeff.	Inter-cept Deg.	Slope	Std. Dev. Deg.	Mean Dir. Deg.	Corr. Coeff.	Inter-cept Deg.	Slope	Std. Dev. Deg.
Day	118	207	110	194	.995	14	.989	11	186	.97	44	.875	27	184	.92	60	.795	44	167	.91	71	.813	46
Day Clear	56	213	112	200	.994	14	.992	12	191	.961	57	.815	31	190	.93	67	.765	41	185	.86	65	.800	57
Day Cloudy	62	201	109	189	.996	15	.987	9	182	.985	29	.947	19	179	.90	53	.828	47	151	.956	75	.842	32
Night	191	185	75	176	.79	50	.766	47	157	.72	92	.591	52	145	.72	111	.510	52	159	.59	100	.534	61
Night Clear	93	161	75	155	.69	45	.750	54	142	.67	83	.550	56	124	.70	102	.481	54	151	.53	85	.503	64
Night Cloudy	98	208	68	197	.84	64	.730	37	172	.77	108	.578	44	166	.72	126	.492	48	166	.65	121	.518	52
Trans AM	45	173	87	152	.93	43	.855	33	141	.81	79	.668	52	143	.73	95	.547	60	164	.75	78	.582	59
Trans PM	51	226	60	205	.93	9	1.06	22	213	.81	121	.491	36	192	.77	118	.562	39	188	.77	77	.794	39
24 Hour 17 Days	405	195	88	182	.91	31	.898	37	171	.85	75	.704	46	162	.81	93	.630	51	165	.77	81	.690	57

Table B-6

TRACT AND PICEANCE CREEK STATION CORRELATIONS WITH MET TOWER AT 100 FEET

b. Piceance Creek Stations

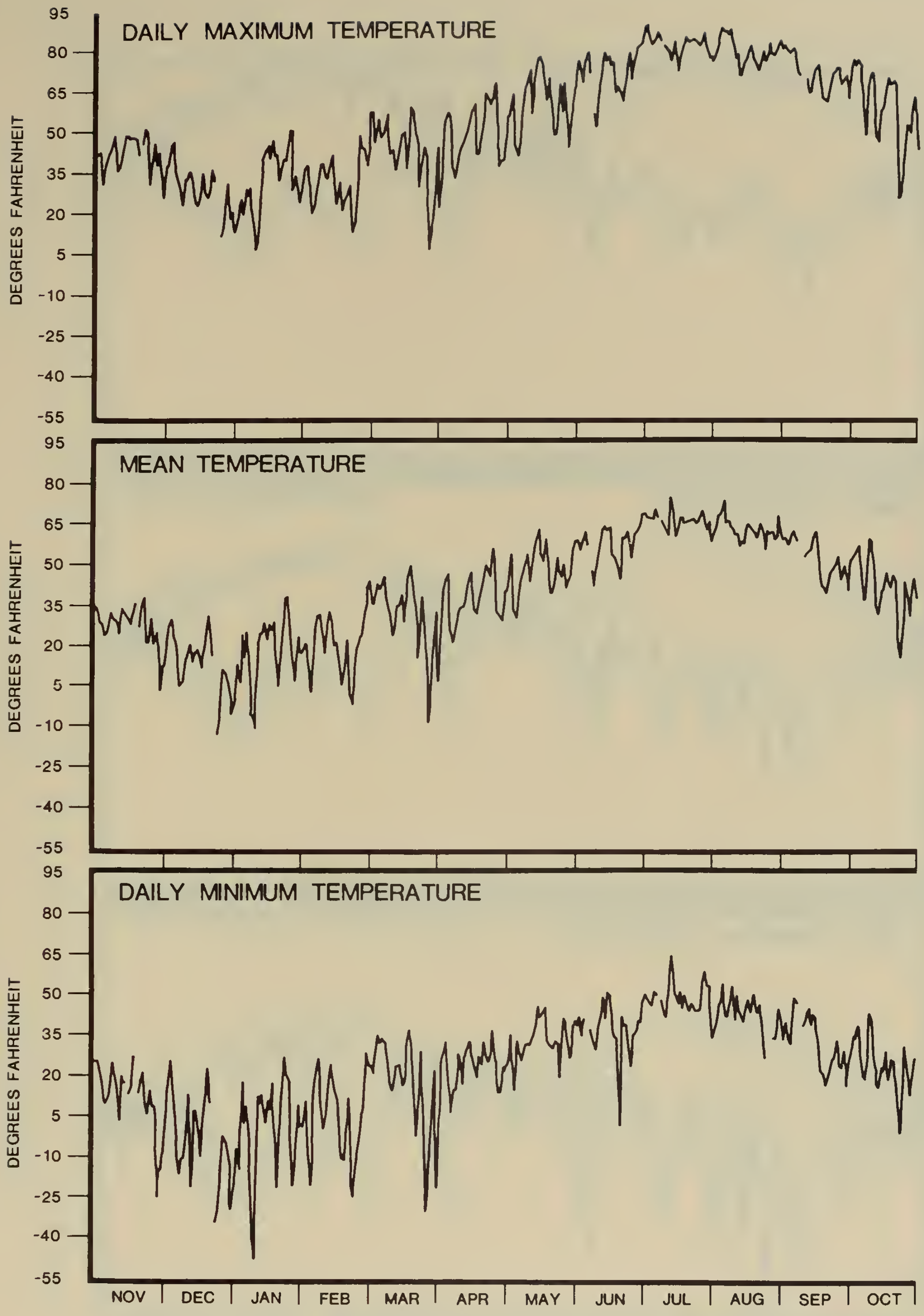
OBSERVATIONS		MET TOWER 100 Ft. Elevation		MRI 031					TRAILER 021					TRAILER 020					TRAILER 022				
Time	No.	Mean Deg.	Std. Dev. Deg.	Mean Dir. Deg.	Corr. Coeff.	Inter-cept Deg.	Slope	Std. Dev. Deg.	Mean Dir. Deg.	Corr. Coeff.	Inter-cept Deg.	Slope	Std. Dev. Deg.	Mean Dir. Deg.	Corr. Coeff.	Inter-cept Deg.	Slope	Std. Dev. Deg.	Mean Dir. Deg.	Corr. Coeff.	Inter-cept Deg.	Slope	Std. Dev. Deg.
Day	118	207	110	195 (352) (up creek)	.86	75	.676	56	174 (314)	.91	76	.750	46	183 (295)	.94	63	.784	38	168 (291)	.88	80	.751	52
Day Clear	56	213	112	195	.85	94	.612	59	189	.92	76	.723	45	182	.96	69	.791	32	180	.84	85	.710	62
Day Cloudy	62	201	109	196	.89	52	.763	51	160	.91	74	.791	46	184	.92	58	.778	43	158	.93	76	.793	41
Night	191	185	75	181 (172) (down creek)	.53	86	.544	64	136 (134)	.58	121	.471	61	148 (115)	.63	108	.523	58	158 (111)	.65	110	.471	57
Night Clear	93	161	75	168	.46	91	.418	67	118	.48	118	.369	66	136	.53	98	.462	64	155	.62	91	.451	59
Night Cloudy	98	208	68	194	.58	80	.658	56	153	.66	127	.527	52	159	.72	124	.527	48	161	.73	131	.478	47
Trans AM	45	173	87	187	.69	73	.536	64	118	.75	109	.541	59	145	.71	100	.502	63	158	.67	87	.542	66
Trans PM	51	226	60	203	.57	138	.432	50	177	.68	162	.358	45	194	.77	157	.352	39	202	.80	155	.351	37
24 Hour 17 Days	405	195	88	189	.72	79	.614	61	150	.76	107	.758	57	164	.78	97	.601	55	167	.75	101	.564	58

Note: Parenthetical values are up creek directions for Day and down creek directions for Night.

B.1.2 Temperature Fields

The following figures and tables support Section 3.1.2.5, Temperature Fields:

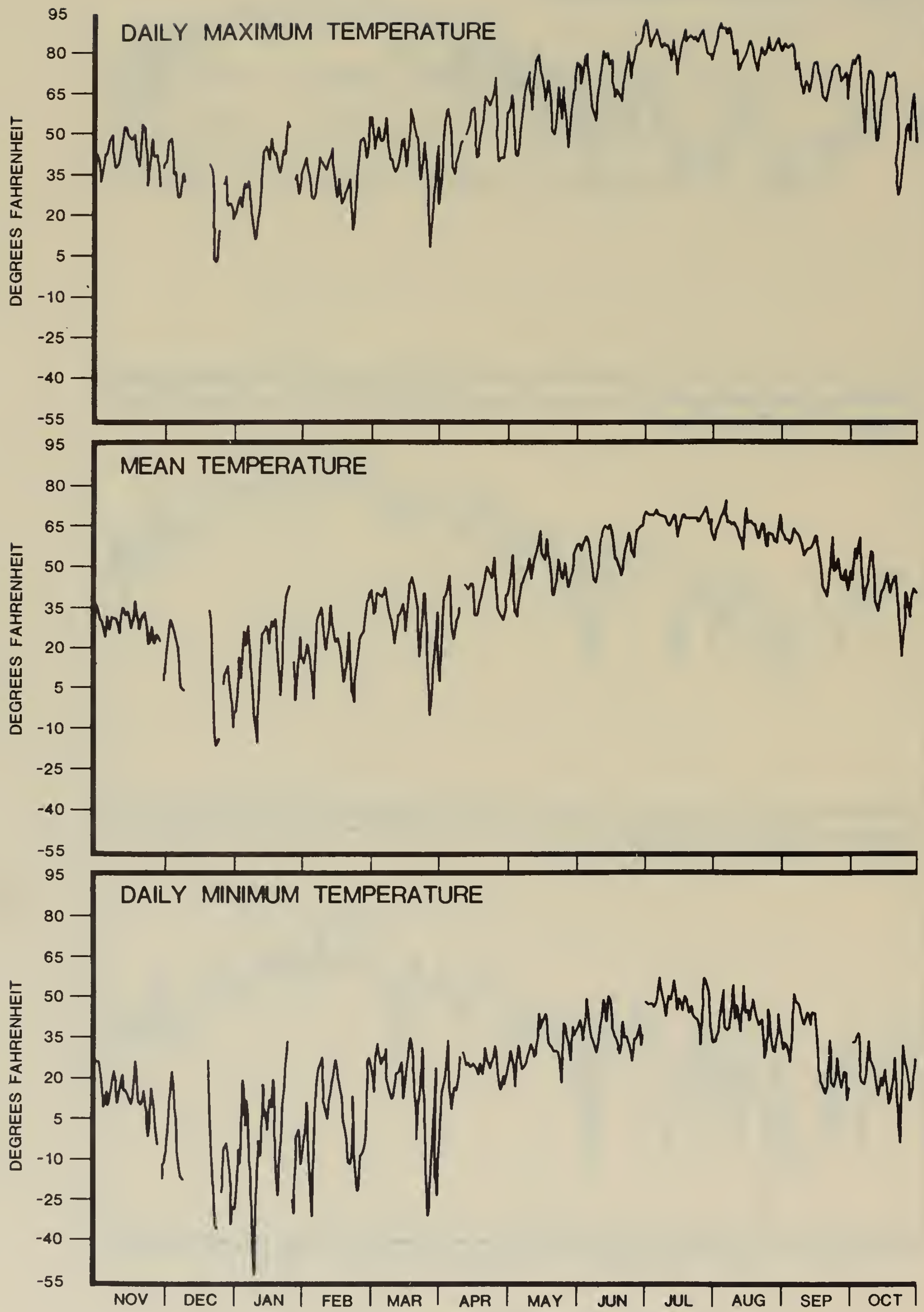
	Annual Time Series of 24-Hour Mean, Max, and Min Temp '74-'75
Figure B-5a	Station 020
Figure B-5b	Station 021
Figure B-5c	Station 022
Figure B-5d	Station 023
Figure B-5e	Station 024
	Annual Time Series of 24-Hour Mean, Max, and Min Temp '75-'76
Figure B-6a	Station 020
Figure B-6b	Station 021
Figure B-6c	Station 022
Figure B-6d	Station 023
Figure B-6e	Station 024
	Diurnal Variations in the Probability of an Inversion and its Mean Height by Month
Figure B-7a	Winter
Figure B-7b	Spring
Figure B-7c	Summer
Figure B-7d	Fall
Figure B-8	Frequency Analyses of Inversion Durations for 360 Observations at Station 023 from 7 December 1974 to 2 November 1976
Table B-7	Meteorological Summary: Temperature and Relative Humidity
	a. 1974-1975
	b. 1975-1976



STATION 020 1974-1975

ANNUAL TIME SERIES OF 24-HOUR MEAN, MAXIMUM, AND MINIMUM TEMPERATURES

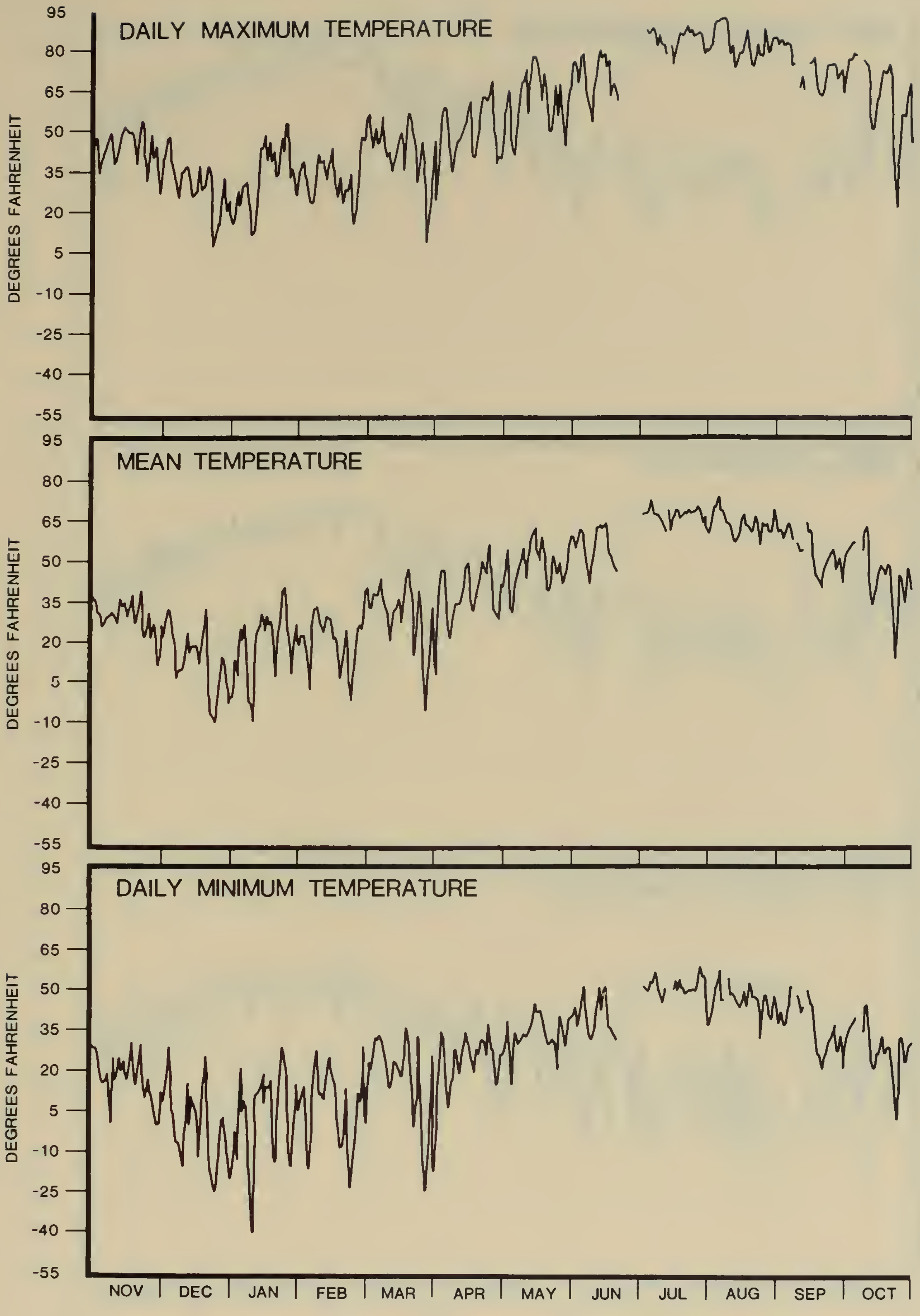
FIGURE B-5a



STATION 021 1974-1975

ANNUAL TIME SERIES OF 24-HOUR MEAN, MAXIMUM, AND MINIMUM TEMPERATURES

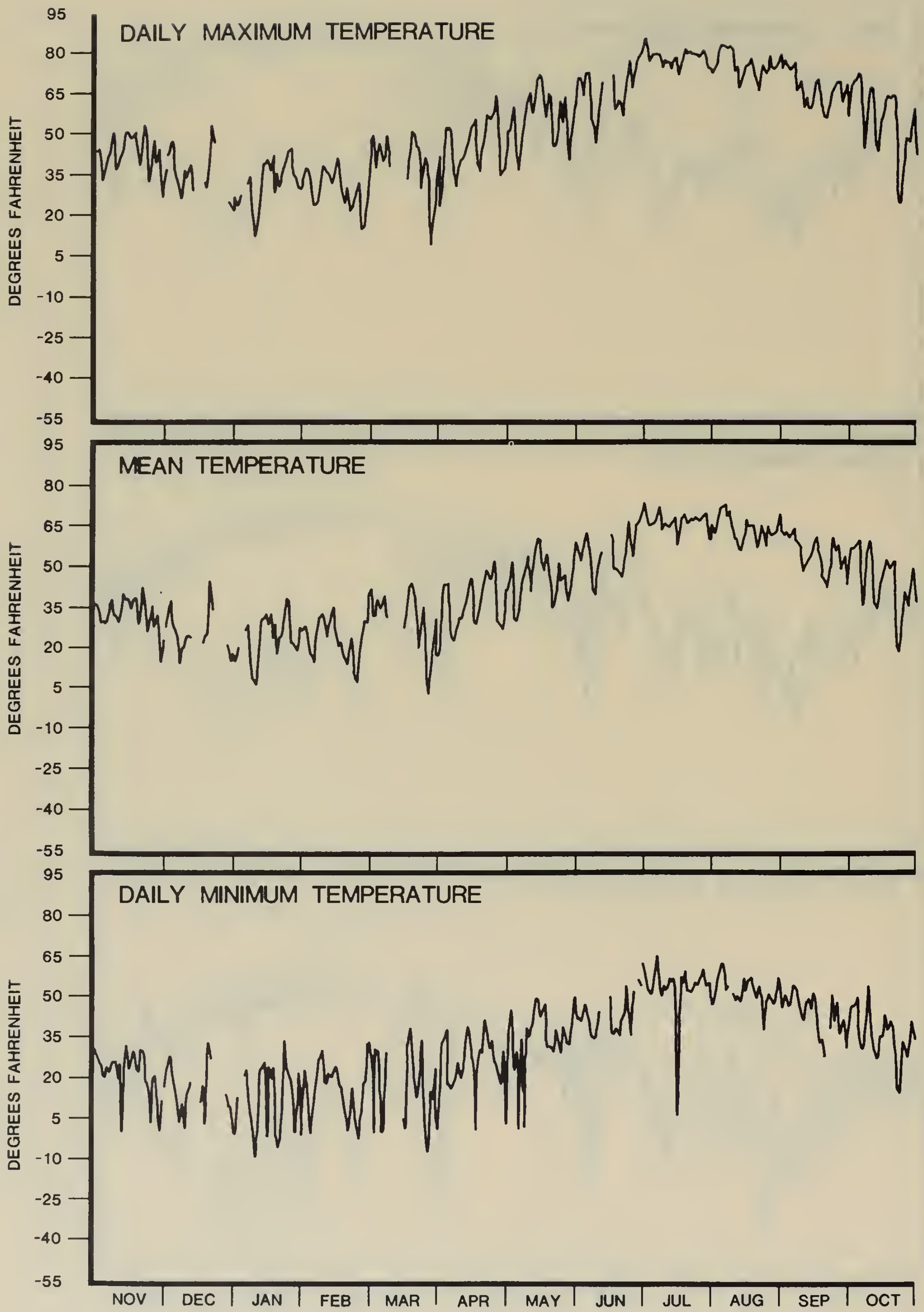
FIGURE B-5b



STATION 022 1974-1975

ANNUAL TIME SERIES OF 24-HOUR MEAN, MAXIMUM, AND MINIMUM TEMPERATURES

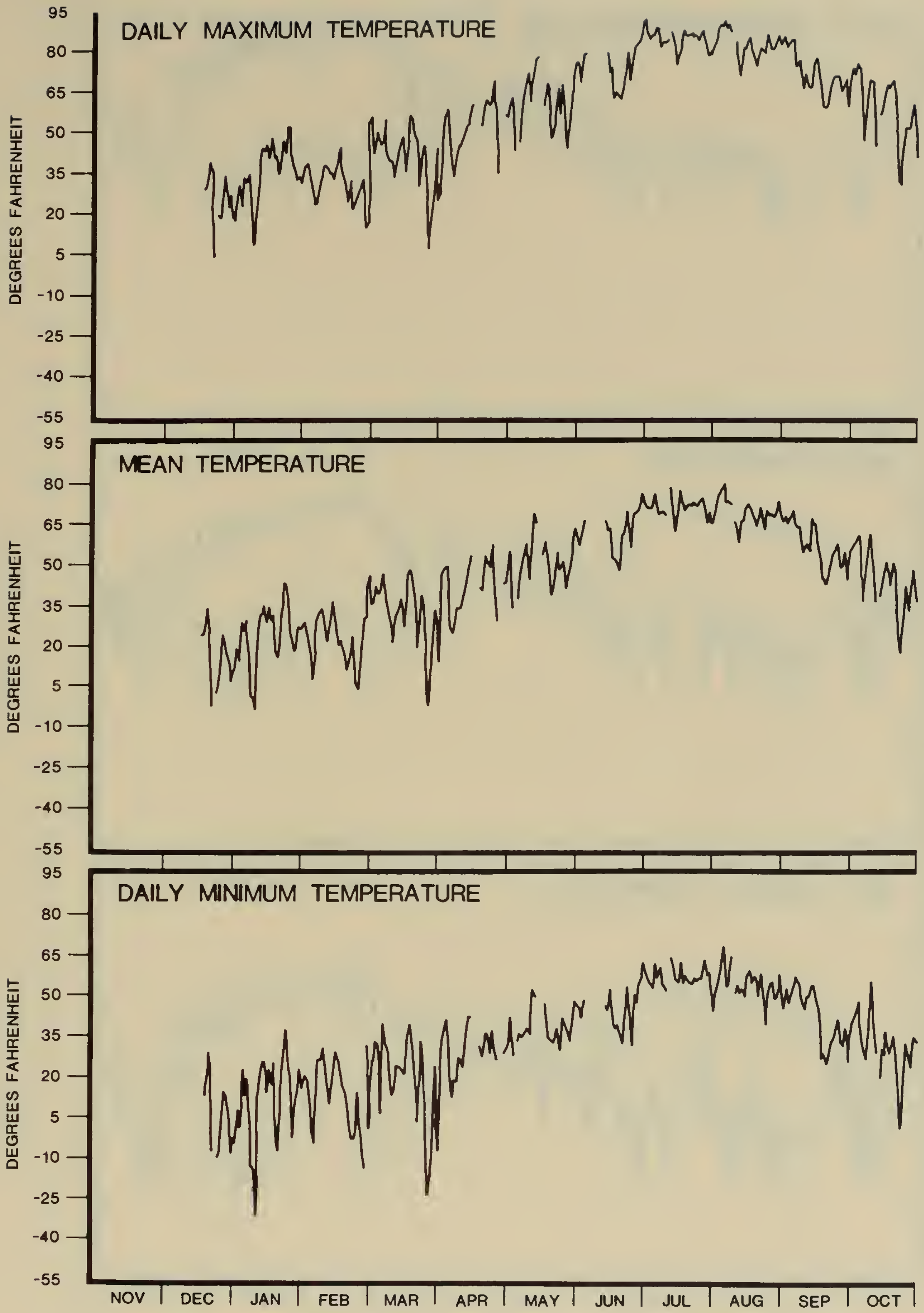
FIGURE B-5c



STATION 023 1974-1975

ANNUAL TIME SERIES OF 24-HOUR MEAN, MAXIMUM, AND MINIMUM TEMPERATURES

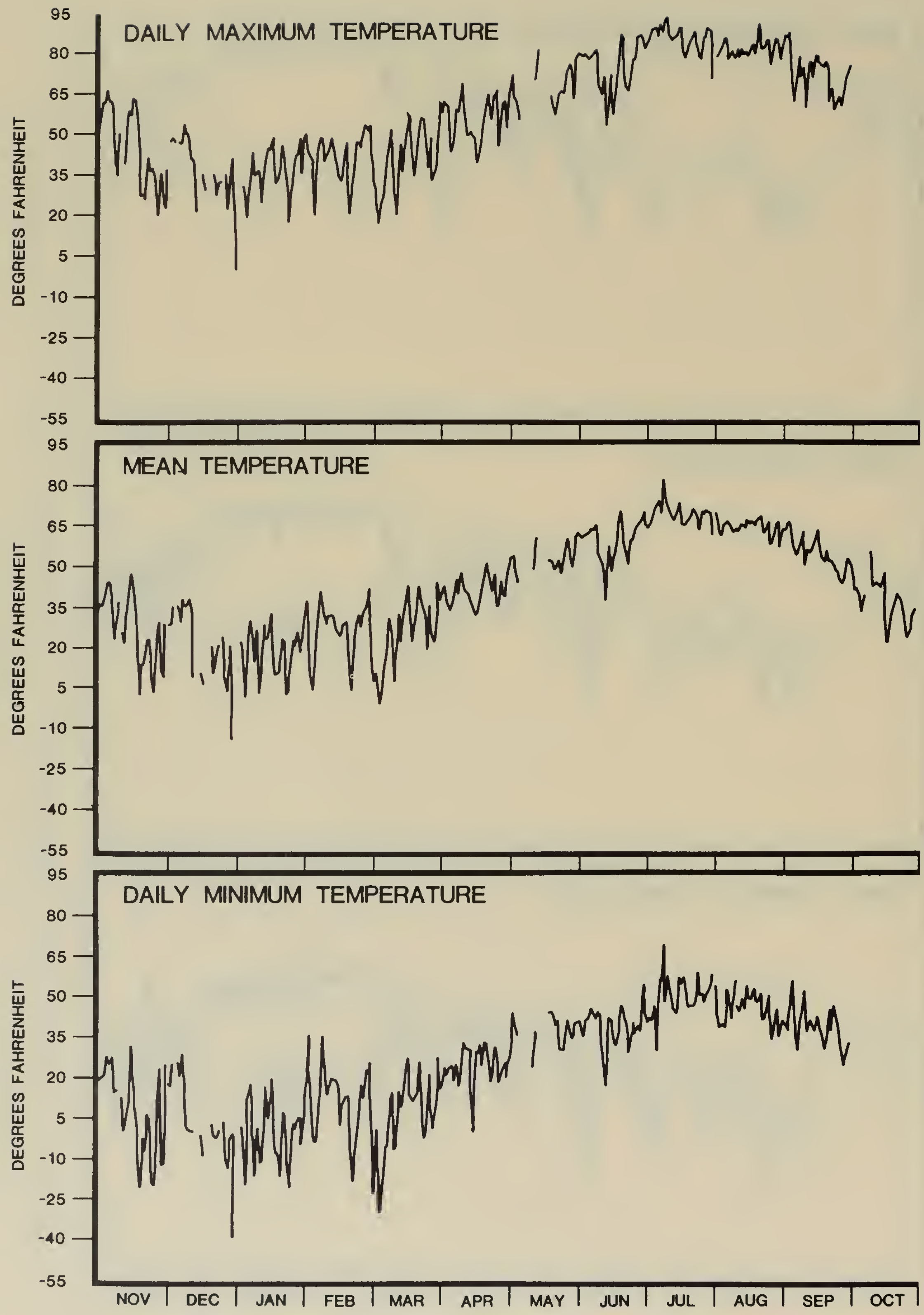
FIGURE B-5d



STATION 024 1974-1975

ANNUAL TIME SERIES OF 24-HOUR MEAN, MAXIMUM, AND MINIMUM TEMPERATURES

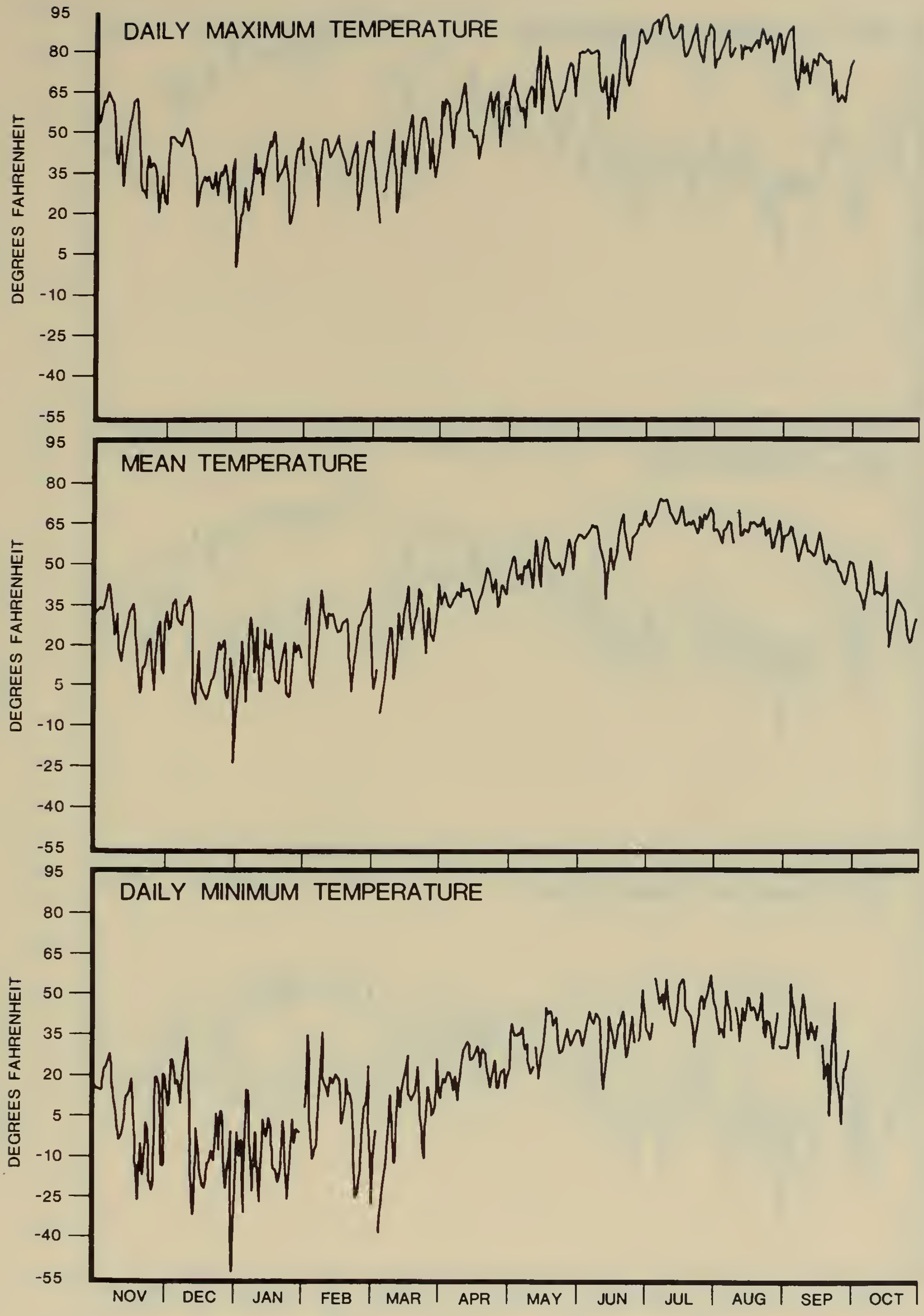
FIGURE B-5e



STATION 020 1975-1976

ANNUAL TIME SERIES OF 24-HOUR MEAN, MAXIMUM, AND MINIMUM TEMPERATURES

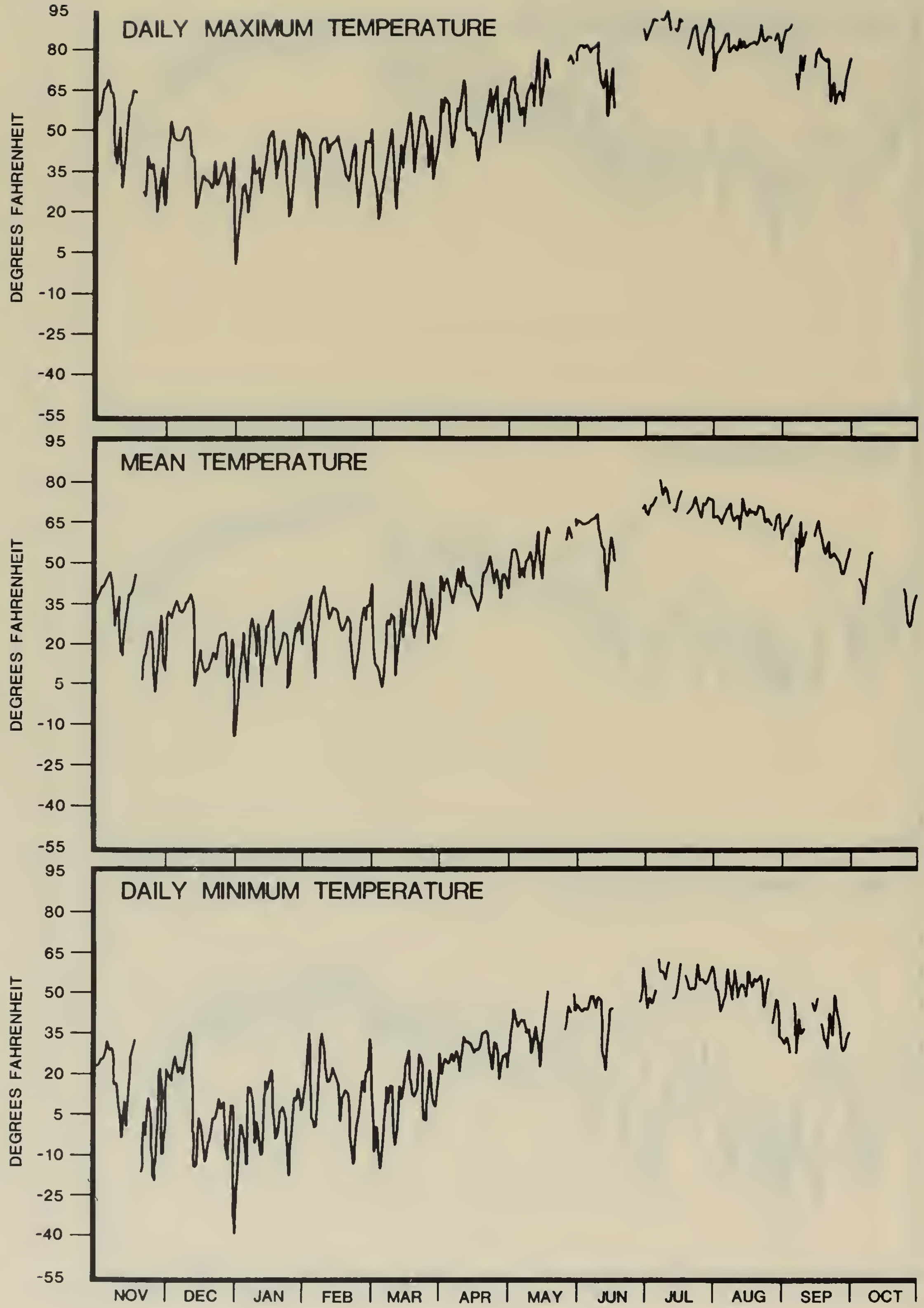
FIGURE B-6a



STATION 021 1975-1976

ANNUAL TIME SERIES OF 24-HOUR MEAN, MAXIMUM, AND MINIMUM TEMPERATURES

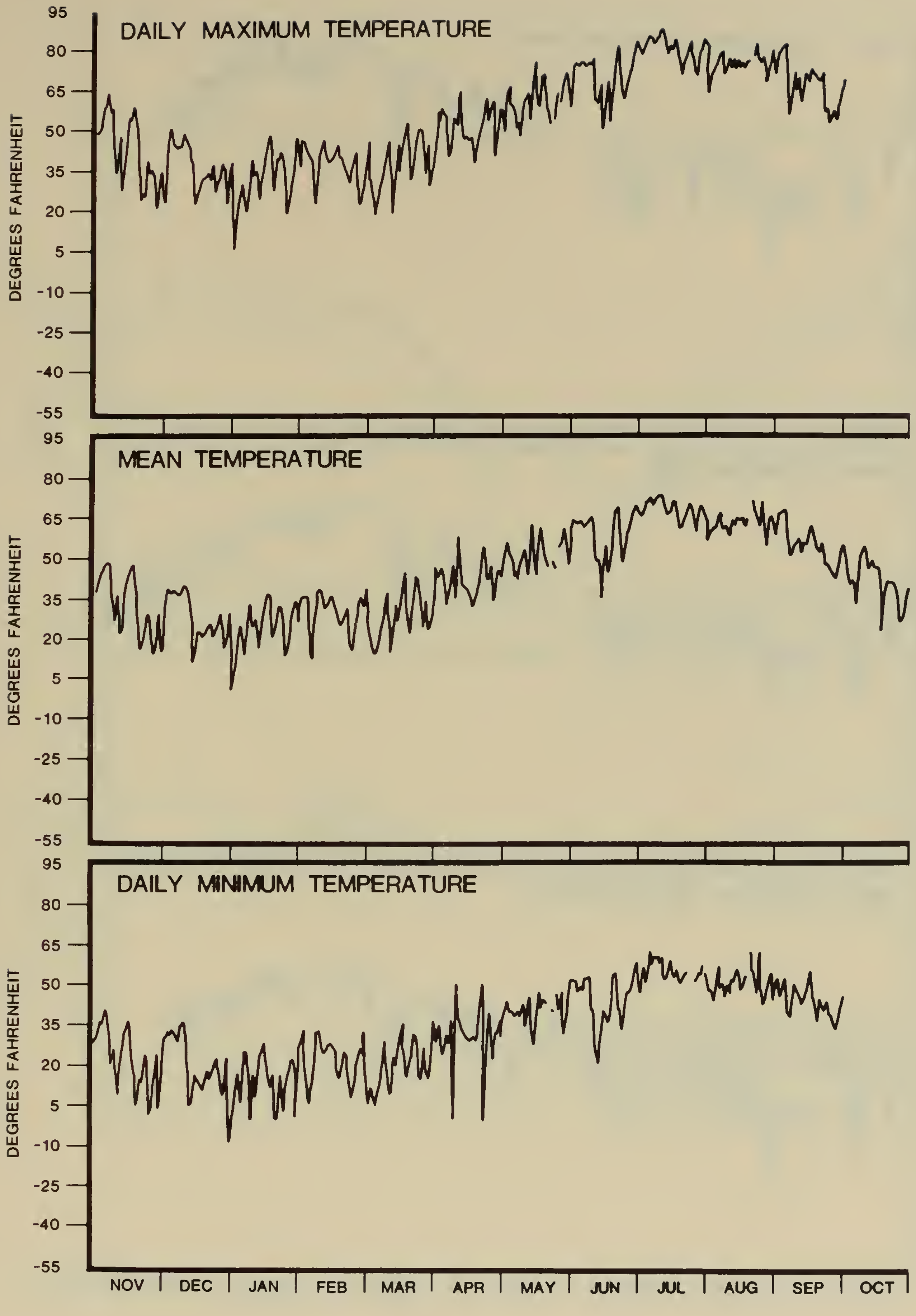
FIGURE B-6b



STATION 022 1975-1976

ANNUAL TIME SERIES OF 24-HOUR MEAN, MAXIMUM, AND MINIMUM TEMPERATURES

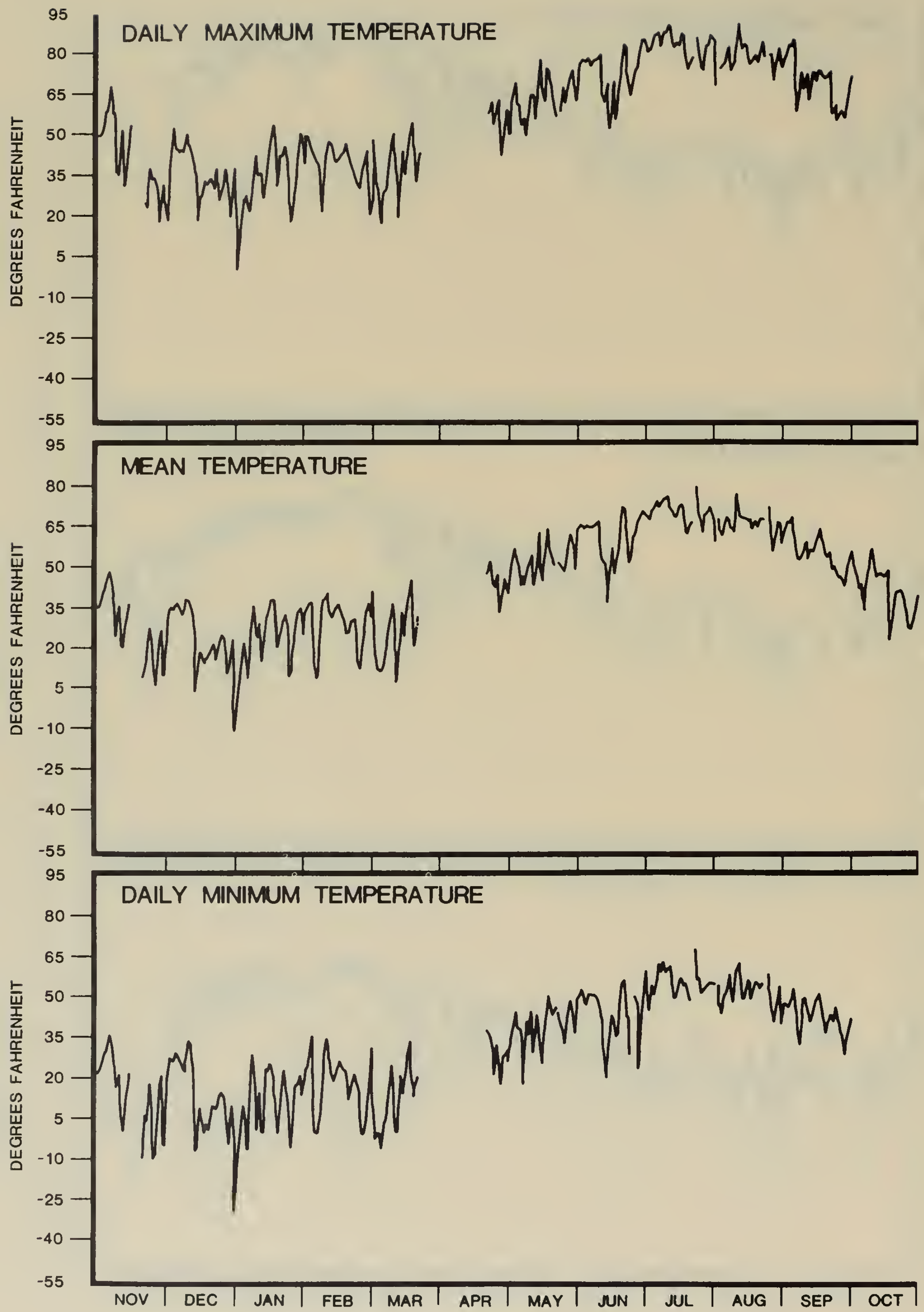
FIGURE B-6c



STATION 023 1975-1976

ANNUAL TIME SERIES OF 24-HOUR MEAN, MAXIMUM, AND MINIMUM TEMPERATURES

FIGURE B-6d



STATION 024 1975-1976

ANNUAL TIME SERIES OF 24-HOUR MEAN, MAXIMUM, AND MINIMUM TEMPERATURES

FIGURE B-6e

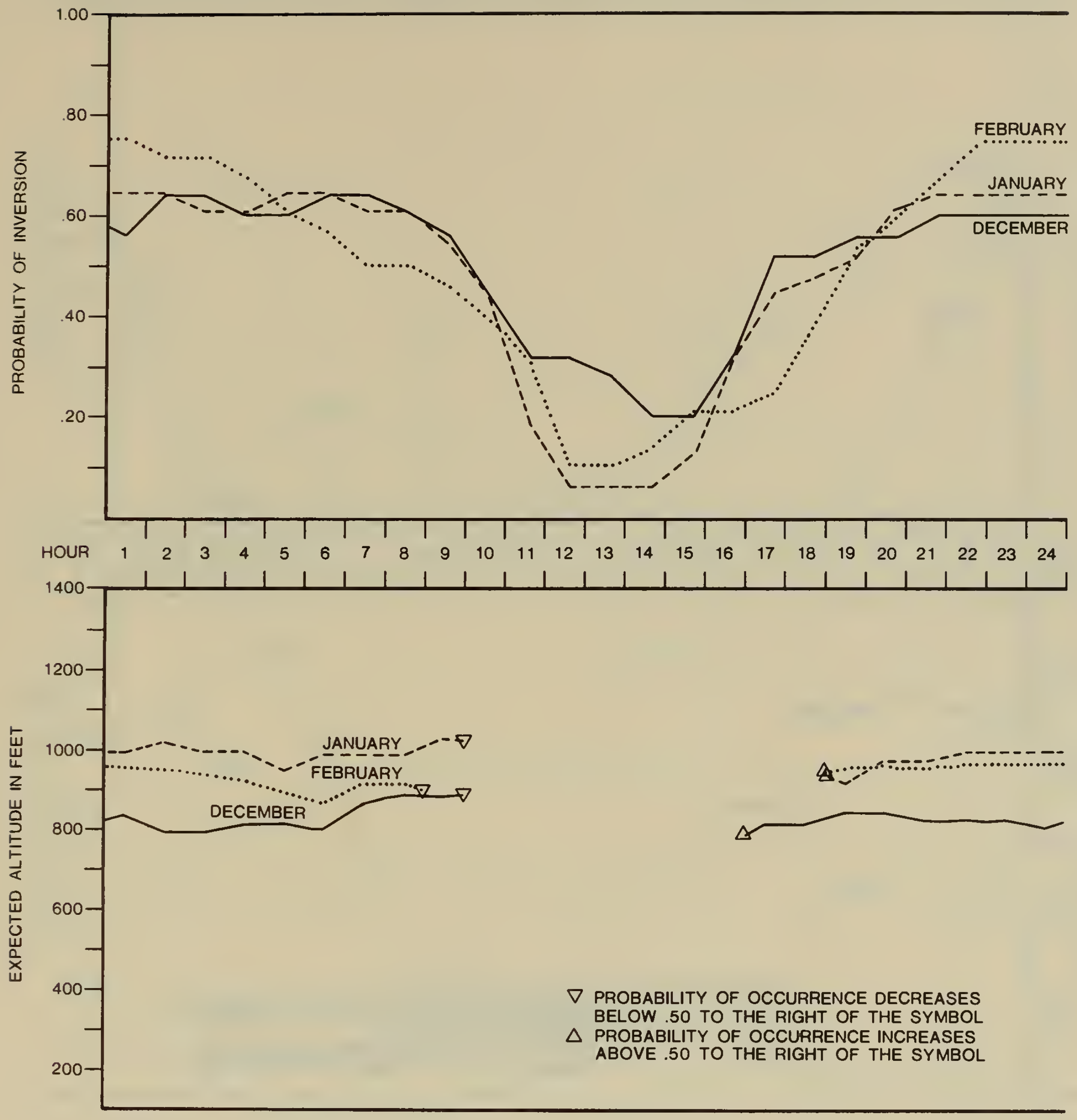


FIGURE B-7a

DIURNAL VARIATIONS IN THE PROBABILITY OF AN INVERSION AND ITS MEAN HEIGHT BY MONTH a. WINTER QUARTER

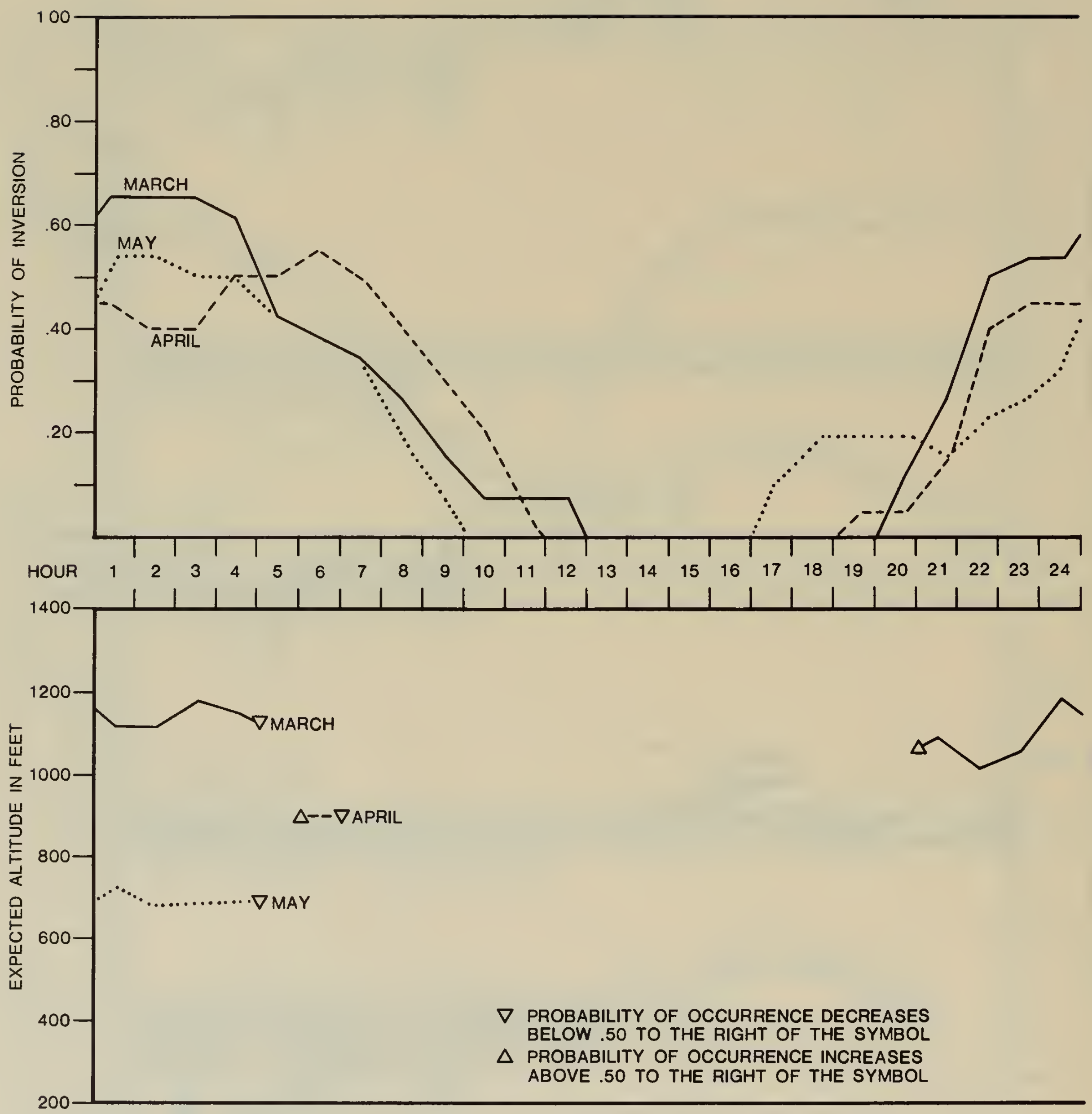


FIGURE B-7b

DIURNAL VARIATIONS IN THE PROBABILITY OF AN INVERSION AND ITS MEAN HEIGHT BY MONTH b. SPRING QUARTER

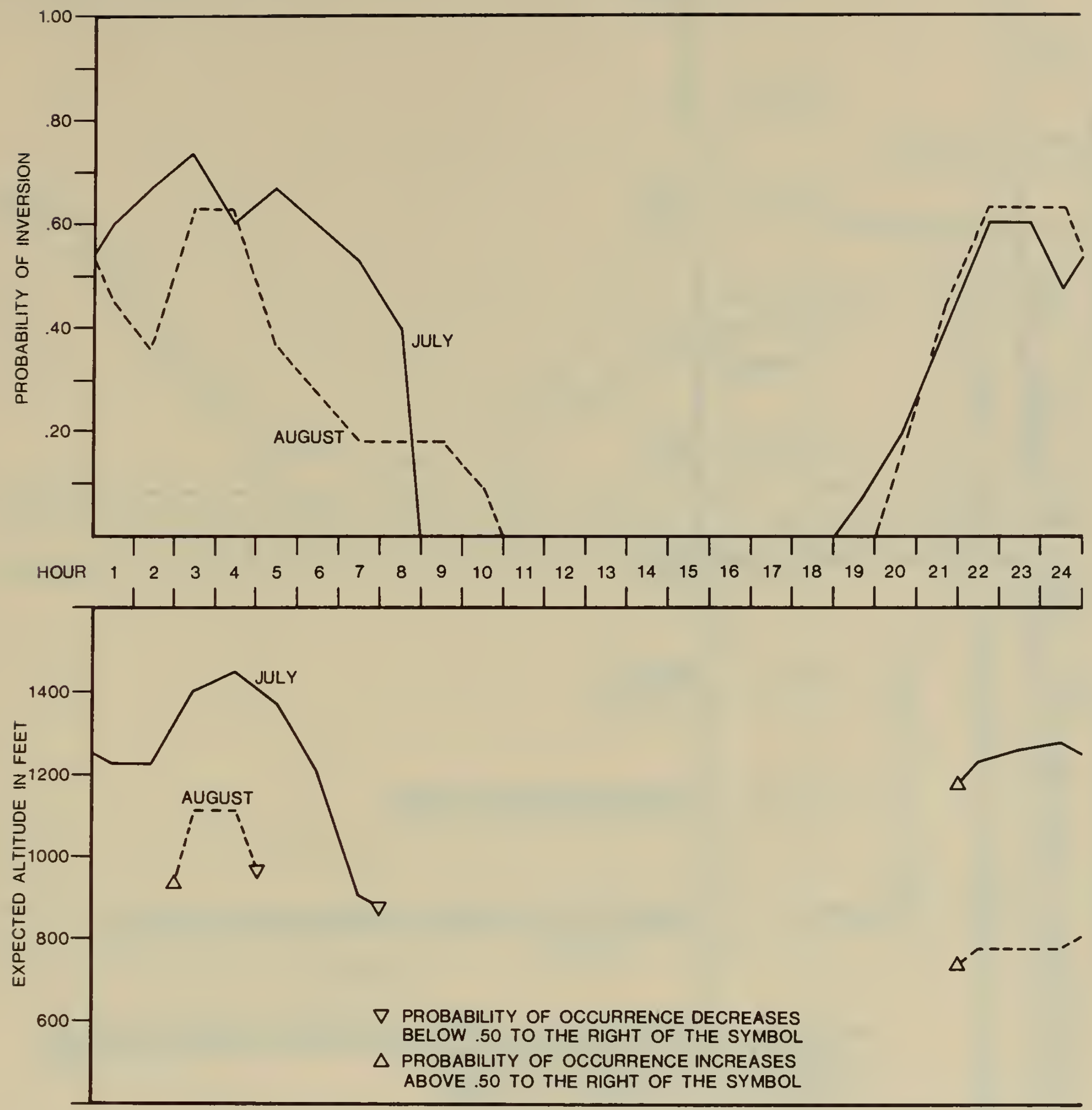


FIGURE B-7c

DIURNAL VARIATIONS IN THE PROBABILITY OF AN INVERSION AND ITS MEAN HEIGHT BY MONTH c. SUMMER QUARTER

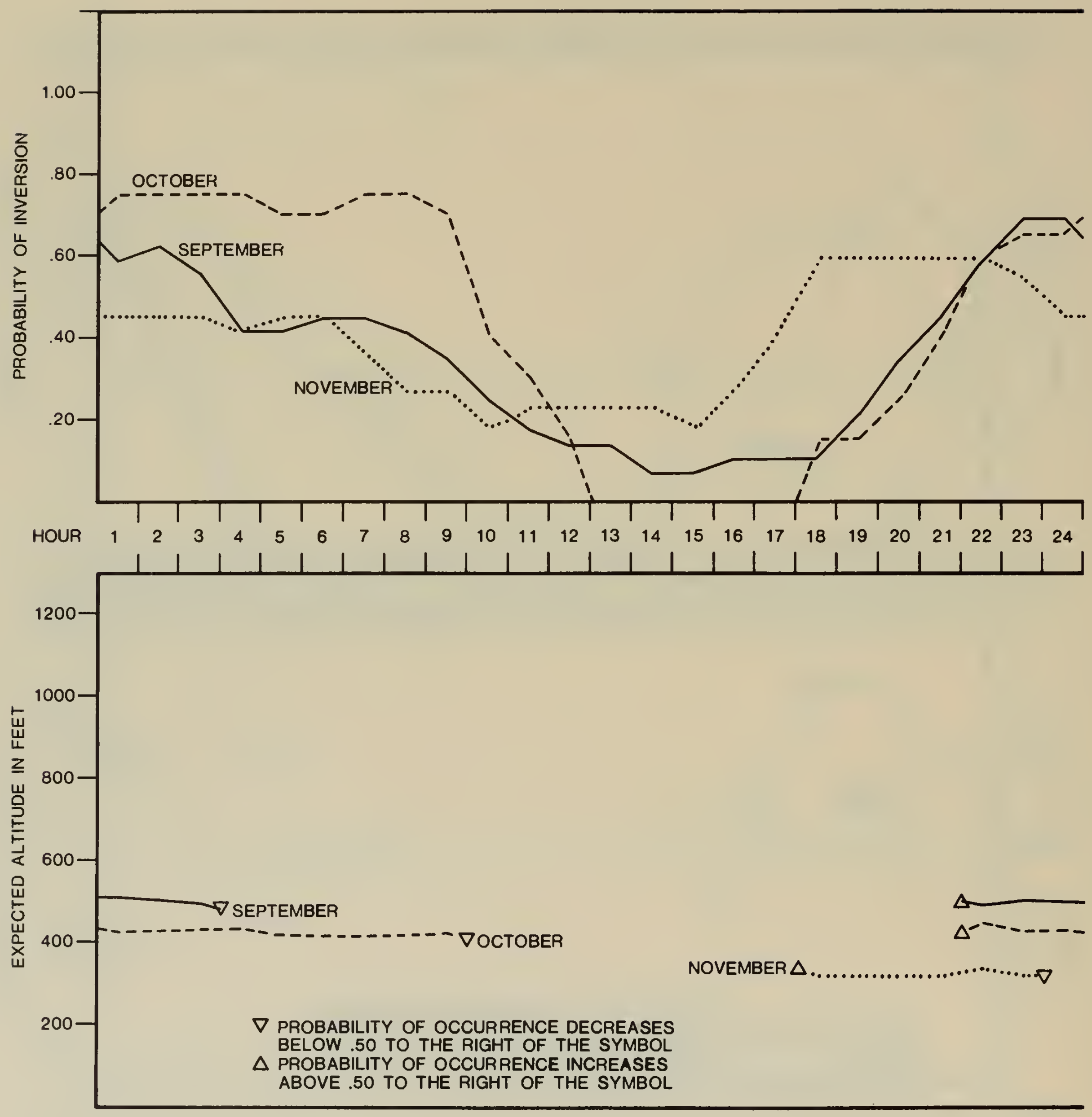
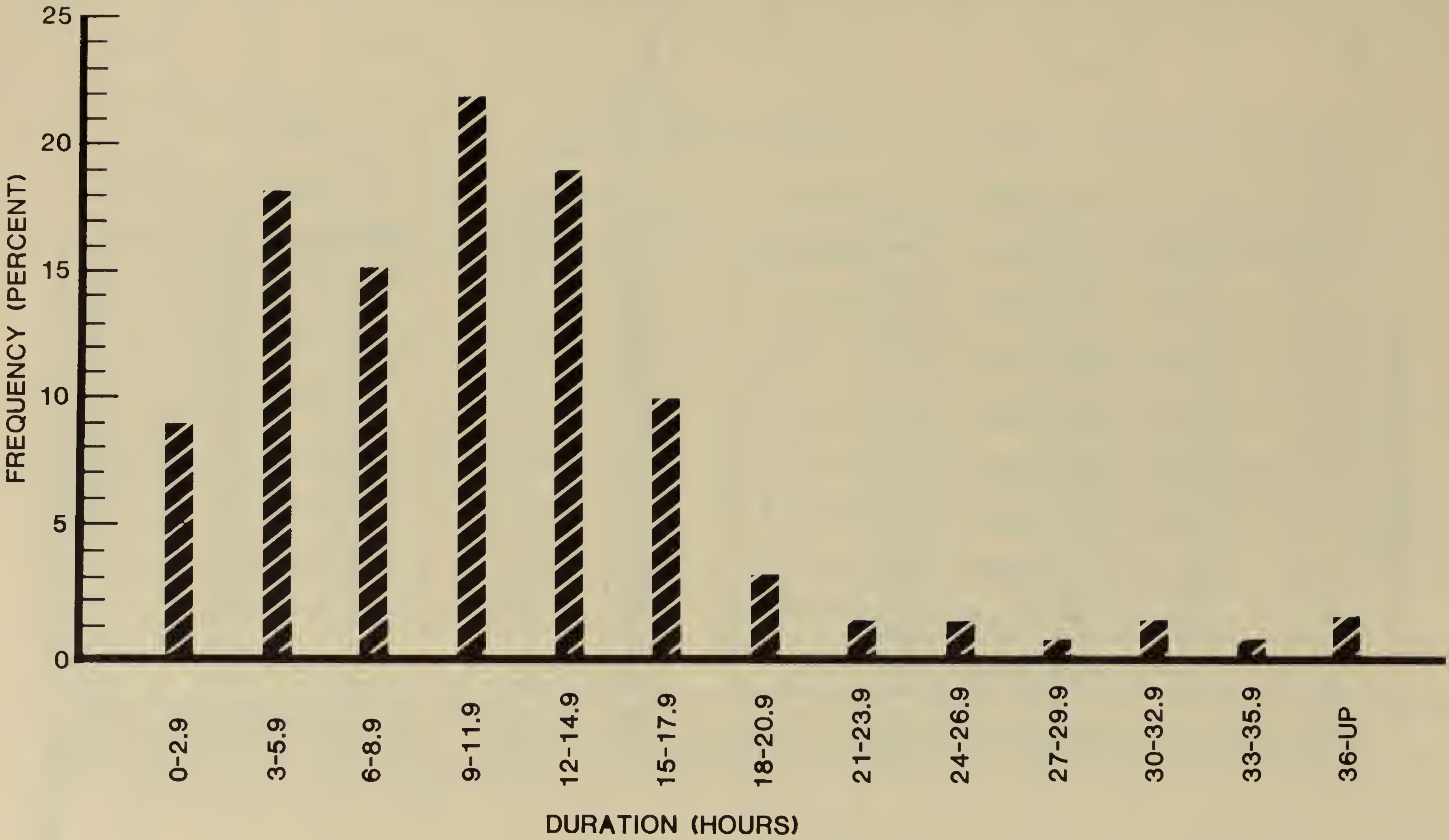


FIGURE B-7d

DIURNAL VARIATIONS IN THE PROBABILITY OF AN INVERSION AND ITS MEAN HEIGHT BY MONTH d. FALL QUARTER



FREQUENCY ANALYSIS OF INVERSION DURATIONS FOR 360 OBSERVATIONS

AT STATION 023 FROM 7 DECEMBER 1974 TO 2 NOVEMBER 1976

FIGURE B-8

Table B-7
METEOROLOGICAL SUMMARY: TEMPERATURE AND RELATIVE HUMIDITY
1974-1975

TRAILER	ITEM	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	ANNUAL
020	Temperature, Hourly Max. (^oF)	50	45	50	47	59	69	78	87	89	88	83	77	
021		52	46	53	49	57	68	78	88	90	90	83	79	
022		53	47	53	47	55	68	77	78	87	89	83	78	
023		48	49	43	42	50	68	71	83	84	82	78	71	
024		(1)	37	51	47	55	62	77	87	90	90	83	74	
020	Temperature, Hourly Min. (^oF)	-14	-30	-46	-24	-28	-19	15	30	42	29	17	0	
021		-17	-34	-51	-29	-28	-21	16	25	37	29	14	-1	
022		0	-22	-38	-22	-23	-15	14	31	45	32	19	2	
023		5	0	-5	0	-6	6	22	34	51	40	29	14	
024		(1)	-8	-29	-10	-18	-5	28	32	51	38	24	9	
020	Temperature, Hourly Avg. (^oF)	27	13	15	19	32	36	48	58	67	63	53	42	39
021		27	11	15	20	30	35	47	56	67	63	53	40	39
		29	15	18	21	30	36	48	56	68	64	55	45	40
		32	25	23	24	31	35	46	56	67	65	56	47	42
		(1)	15	22	24	32	38	49	61	71	69	58	45	44
020	Rel. Hum., Hrly Max. (%)	100	100	96	98	100	99	100	98	99	99	98	100	
021		85	95	100	100	100	100	100	100	100	100	100	100	
022		100	100	100	100	100	100	100	100	90	100	100	100	
023		100	100	100	100	100	100	100	100	100	87	93	100	
024		100	100	100	100	100	100	100	95	96	94	99	100	
020	Rel. Hum., Hrly Min. (%)	22	23	24	22	23	15	12	9	10	12	13	13	
021		19	22	26	29	30	22	12	8	10	11	15	15	
022		26	27	30	27	28	19	17	19	21	16	17	17	
023		24	25	26	32	37	32	28	25	28	12	16	15	
024		25	25	26	26	28	16	16	11	12	15	16	16	
020	Rel. Hum., Hrly Avg. (%)	66	72	66	65	64	45	54	47	49	39	41	46	55
021		63	74	75	73	70	65	58	53	56	43	49	55	61
022		70	74	71	71	70	61	58	59	57	44	45	49	61
023		63	69	68	72	72	67	64	54	54	29	35	40	57
024		62	69	65	66	66	55	51	38	45	34	38	41	53

1975-1976

TRAILER	ITEM	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	ANNUAL
020	Temperature, Hourly Max. (^oF)	64	52	47	52	55	68	80(2)	86	93	88	86	77	
021		64	50	47	52	55	68	81	87	92	87	88	75	
022		68	52	48	52	55	67	79(2)	86(2)	94(2)	88	86	78(2)	
023		63	50	47	48	51	63	74	82	87	81	81	71	
024		(1)	51	52	50	53	61(2)	77	84	90	89	83	74	
020	Temperature, Hourly Min. (^oF)	-17	-14	-42	-21	-25	16	19(2)	17	40	34	25	6	
021		-21	-27	-50	-18	-34	12	16	17	34	31	23	0	
022		-18	-12	-36	-9	-13	18	21(2)	17(2)	44(2)	38	28	9(2)	
023		4	6	-6	6	5	22	27	21	50	43	35	15	
024		(1)	-5	-26	0	-1	18(2)	25	20	46	41	29	13	
020	Temperature, Hourly Avg. (^oF)	26	22	16	27	25	40	52	59	69	64	56	38	41
021		24	19	12	26	24	40	51	59	69	64	55	37	40
022		27	21	17	28	26	41	52	61	71	67	57	4(2)	42
023		32	28	24	31	29	42	52	60	69	64	56	43	44
024		(1)	23	22	31	26	43(2)	52	61	70	66	56	42	43
020	Rel. Hum., Hrly Max. (%)	100	98	99	98	99	100	98(2)	98	92	98	98	96	
021		100	100	100	100	100	100	100	100	100	100	100	100	
022		100	100	100	100	100	100	100(2)	98(2)	93(2)	98	100	98(2)	
023		100	90	90	89	90	98	90	99	96	100	99	94	
024		100	98	100	100	100	100	100	100	99	100	100	100	
020	Rel. Hum., Hrly Min. (%)	16	32	28	21	20	14	13(2)	13	14	15	15	17	
021		19	36	35	25	24	17	19	15	15	16	16	18	
022		22	35	33	27	25	20	20(2)	13(2)	17(2)	18	17	18(2)	
023		19	34	25	22	23	21	24	27	29	32	32	32	
024		22	32	29	26	30	21	21	16	16	20	18	19	
020	Rel. Hum., Hrly Avg. (%)	61	73	70	63	61	54	52	39	41	44	54	47	55
021		70	81	78	70	67	59	60	44	46	49	60	53	61
022		66	77	74	67	64	58	52	42	42	44	57	54(2)	58
023		53	62	62	57	56	53	51	44	47	50	59	51	54
024		58	67	67	67	65	56	54	39	40	41	54	44	54

(1) = Missing (2) = Partial Data Only

Table B-8

MONTHLY INVERSION STATISTICS
STATION 023

Month	Year	No. of Days of Measurement	No. of Inversions Recorded	Heights (ft.) Mean	Heights (ft.) Std. Dev.	Median Time of Onset	Median Time of Breakup	Durations (hrs.) Mean	Durations (hrs.) Std. Dev.
December	1974	24	17	889	343	17:30	06:00	14.1	9
January	1975	31	23	1344	551	17:30	07:30	15.0	8
February	1975	28	28	1027	327	19:00	06:00	12.1	7
March	1975	26	26	1284	553	22:15	03:45	6.0	4
April	1975	21	17	926	355	23:00	08:00	4.4	3
May	1975	25	20	987	275	21:30	04:15	6.3	3
June (1)	1975	0	(1)	(1)	(1)	(1)	(1)	(1)	(1)
July	1975	15	15	1181	378	21:30	01:00	2.8	2
August	1975	11	8	875	443	21:00	04:00	7.1	4
September	1975	28	22	478	139	22:00	07:45	9.3	5
October	1975	20	14	399	84	21:00	08:45	10.9	4
November	1975	22	14	349	105	17:30	05:00	12.1	7
December	1975	33	22	551	288	20:00	06:15	13.9	7
January	1976	24	17	521	385	19:30	24:00	14.0	10
February	1976	28	16	497	278	18:30	08:45	12.6	5
March	1976	31	20	407	98	19:00	08:00	11.1	4
April	1976	5	5	358	72	20:00	05:30	8.9	3
May	1976	22	22	694	277	20:00	06:45	10.2	3
June	1976	20	13	466	141	20:00	06:30	9.5	1
July (1)	1976	0	(1)	(1)	(1)	(1)	(1)	(1)	(1)
August	1976	21	17	719	208	22:00	05:00	6.9	3
September	1976	21	15	834	234	21:00	07:30	8.2	4
October	1976	25	22	555	150	19:45	08:30	11.8	2
November	1976	2	2	573	118	22:30	06:45	8.3	2
1st Year	1974-1975	251	204	885	343	21:00	06:00	8.8	4.1
2nd Year	1975-1976	232	171	561	140	20:00	07:00	10.3	2.4
Two Year	1974-1976	483	375	723	305	20:30	06:30	9.8	3.3

(1) No measurements were made in June, 1975 or July, 1976.

Table B-9

MONTHLY INVERSION STATISTICS
STATION 021

Month	Year	No. of Days of Measurement	No. of Inversions Recorded	Heights (ft.) Mean	Heights (ft.) Std. Dev.	Median Time of Onset	Median Time of Breakup	Durations (hrs.) Mean	Durations (hrs.) Std. Dev.
July	1975	15	14	1025	328	22:00	06:45	6.3	3.8
August	1975	26	5	949	128	20:00	07:00	9.0	3.8
September	1975	13	9	1309	238	21:00	05:00	7.9	4.7
October (1)	1975	0	(1)	(1)	(1)	(1)	(1)	(1)	(1)
November	1975	23	18	1665	211	19:30	22:30	14.5	7.1
December	1975	10	9	2843	184	20:30	04:30	10.4	5.4
January	1976	18	14	980	291	*	*	*	*
February	1976	24	17	499	359	18:30	08:30	14.2	7.8
March	1976	31	22	344	199	20:45	08:00	10.9	2.8
April	1976	30	26	702	316	21:00	06:45	8.7	3.1
May	1976	21	19	800	331	21:30	05:30	7.9	2.5
June	1976	10	6	1154	443	21:00	04:30	7.0	3.2
July-June	1975-1976	200	159	1115	680	20:30	06:30	9.7	2.8

(1) No measurements were taken in October, 1975.

* Missing Data

Table B-10

MONTHLY INVERSION STATISTICS
STATION 020

Month	Year	No. of Days of Measurement	No. of Inversions Recorded	Heights (ft.)		Median Time of Onset	Median Time of Breakup	Durations (hrs.)	
				Mean	Std. Dev.			Mean	Std. Dev.
June	1976	14	12	1046	374	20:45	06:30	8.0	2.8
July	1976	14	13	875	224	21:00	07:00	8.2	2.7
August	1976	3	2	867	34	20:15	07:45	11.5	1.4
September	1976	1	1	981	-	23:30	09:30	10.0	-
October	1976	16	14	901	179	18:15	08:30	12.7	3.5
June-October	1976	48	42	934	77	20:30	07:00	10.1	2.0

In addition to presentation of the above data, a detailed presentation is given on comparison of data on temperature profiles from different sources.

B.1.2.1 Comparison of Temperature Profiles from the Tower, Aircraft, Sounders, and Tethersonde

Meteorological soundings have been made by means of a 200-foot tower at Station 023, by aircraft in the vicinity of the tower and in the valley below the tower, by acoustic sounders at Stations 020, 021 and 023, and by the tethersonde at Stations 020 and 023. Some tower, acoustic sounder and aircraft data at Station 023 are concurrent. Also some tower, acoustic sounder and tethersonde data at Station 023 are concurrent, but these do not coincide with aircraft data. Unfortunately, the acoustic sounder at Station 023 was not functioning well during the period while the tethersonde soundings were being made there. In drawing comparisons between the data, the tower and tethersonde data are considered first, followed by tethersonde-acoustic sounder data. Aircraft data are then reviewed.

B.1.2.1.1 Tower-Tethersonde Data

Figure 3-6 is a sequence of tethersonde soundings taken alternately at Stations 020 and 023 on a typical June day. Table B-11 is a record of tower measurements made on several days when tethersonde flights were flown at the tower. On 24 June at 0500 MST, five-minute mean temperatures on the tower ranged from 37^{0}F at 8 feet to 39^{0}F at 200 feet. At 0600 MST, the range was from 41^{0}F at 8 feet down to 39^{0}F and back up to 40^{0}F at 100 and 200 feet. During ascent of the tethersonde at 0526 MST, the instantaneous temperature at 4 feet above ground level was 38^{0}F, at 10 feet it was 41^{0}F, and at 200 feet it was 42^{0}F. During descent at 0617 MST, the temperatures were 43^{0}F at 200 feet and 44^{0}F at 4 feet above ground level. It appears that the temperatures as measured by the tethersonde may have been 2 to 3^{0}F warmer than those measured on the tower in this case. A better comparison is given on 23 June when a tethersonde flight was launched at the tower at 0359 MST and reached 592 feet by 0406.1 MST. The tethersonde temperature at the surface was 42.5^{0}F. It increased to 42.8^{0}F at 48 feet and decreased to 39.6^{0}F at 592 feet. Tower temperatures at 0400 MST were 41^{0}F at 8 feet, 43^{0}F at 30 and 100 feet, and 41^{0}F at 200 feet. There is no significant difference in tower and tethersonde data in this case. It is safe to compare temperatures from the two systems for most purposes. They should not be compared for the purpose of obtaining temperature gradients over short distances, e.g., a distance comparable to the height of the tower.

Table B-11 TYPICAL TOWER METEOROLOGICAL DATA DURING TETHERSONDE TEST

		STATION 023																				STATION 020			
Date	Time* MST (Hrs)	Wind Speed (MPH)				Wind Direction (Deg.)				Std. Dev. in Wind Direction (Deg.)				Bar. Pr. (mb)	Air Temp (^{o}F)				Temp. Diff. (^{o}F)		Wind Speed (MPH) 30'	Wind Dir. (Deg) 30'	Std. Dev. Wind Dir. (Deg) 30'	Air Temp (^{o}F) 30'
		8'	30'	100'	200'	8'	30'	100'	200'	8'	30'	100'	200'		8'	30'	100'	200'	100'- 30'	200'- 30'				
6/19/76	0400	3	5	2	0	202	212	190	120	13	11	14	22	795	38	41	44	43	2.96	2.37	0	100	10	31
6/19	0500	2	1	1	2	165	180	52	80	12	16	3	8	795	41	41	43	44	1.66	3.06	0	110	15	30
6/19	0600	0	1	1	2	116	226	188	112	15	52	52	7	796	43	43	45	45	1.09	2.38	0	70	16	34
6/19	0700	1	1	2	1	56	56	77	100	30	26	30	21	796	48	48	47	45	-.72	-1.82	0	98	9	42
6/19	0800	3	4	3	2	48	32	26	348	41	18	33	32	796	54	54	52	51	-.84	-1.96	0	66	14	53
6/19	0900	3	5	5	5	102	301	321	358	180	20	16	108	796	59	60	59	57	-1.08	-2.19	0	346	40	61
6/19	1000	5	6	6	5	17	9	11	77	22	24	38	135	795	65	63	62	61	-1.29	-2.38	0	17	56	66
6/19	1100	6	7	8	7	348	336	338	101	104	90	76	76	795	67	66	64	63	-1.47	-2.45	0	66	60	68
6/19	1200	3	4	4	4	56	173	206	54	116	141	125	145	795	69	68	66	65	-1.50	-2.55	1	302	26	69
6/19	1300	3	4	5	5	169	209	273	286	165	154	154	21	795	71	71	69	68	-1.89	-2.98	0	230	106	72
6/20/76	0600	4	7	10	8	100	104	116	112	13	12	7	7	792	57	57	58	61	.98	4.47	8	130	7	50
6/20	0700	5	8	10	9	98	101	108	112	17	12	11	10	792	63	63	62	63	-.73	.27	5	130	7	59
6/20	0800	12	16	20	22	193	194	194	182	16	12	13	12	792	72	72	71	71	-.97	-1.64	0	92	20	71
6/20	0900	14	17	18	20	190	189	193	182	15	14	12	12	792	75	75	73	73	-1.52	-2.11	7	174	14	78
6/23/76	0300	1	4	4	4	240	228	248	252	13	13	11	6	789	42	42	42	41	.24	-.23	0	56	6	41
6/23	0400	1	2	2	0	142	156	157	206	11	13	12	12	789	41	43	43	41	-.34	-1.07	0	89	24	42
6/23	0500	0	1	1	1	88	121	213	247	7	25	4	7	790	44	42	43	42	.08	-.23	0	62	4	42
6/23	0600	2	3	1	1	224	222	280	299	12	11	13	9	790	43	44	44	43	.18	-.40	0	90	11	42
6/23	0700	1	2	2	1	14	30	48	2	28	26	25	33	790	44	45	44	43	-.86	-1.77	0	160	12	46
6/23	0800	3	4	5	5	356	11	2	298	100	135	120	22	790	50	48	47	46	-.98	-2.00	0	269	15	51
6/23	0900	5	7	9	9	286	321	335	324	93	18	13	12	791	49	49	48	47	-.84	-1.91	1	286	18	52
6/23	1000	3	4	5	5	88	77	38	18	56	97	22	20	790	53	52	51	49	-.81	-2.10	0	2	22	54
6/23	1100	8	10	11	10	206	204	206	197	15	10	13	11	790	54	52	51	50	-1.14	-2.15	2	291	14	56
6/24/76	0500	1	2	2	3	156	112	120	178	58	15	52	20	793	37	38	39	39	1.03	1.32	0	90	13	27
6/24	0600	2	3	3	4	106	108	125	150	16	8	12	11	793	41	39	40	40	1.12	2.04	0	85	26	30
6/24	0700	2	3	3	2	120	101	104	102	28	33	25	33	794	46	44	44	42	-.83	-2.02	3	124	7	39
6/24	0800	2	3	3	2	263	280	280	268	56	26	26	22	794	50	44	48	46	-1.00	-2.06	0	98	13	49
6/24	0900	2	4	4	3	354	352	10	11	94	66	26	30	794	52	51	50	48	-1.10	-2.69	0	46	18	53
6/24	1000	4	6	7	8	188	188	342	302	142	157	78	18	793	55	54	52	51	-1.33	-2.33	0	350	41	56
6/24	1100	7	9	9	8	149	333	338	8	152	32	35	131	793	58	56	54	53	-1.49	-2.52	6	312	26	58
6/24	1200	5	8	10	10	136	18	340	56	162	168	121	121	793	60	59	57	56	-1.53	-2.80	4	293	18	60
6/24	1300	6	8	9	9	260	256	259	240	42	40	34	38	792	62	61	58	57	-2.04	-3.07	6	289	18	62

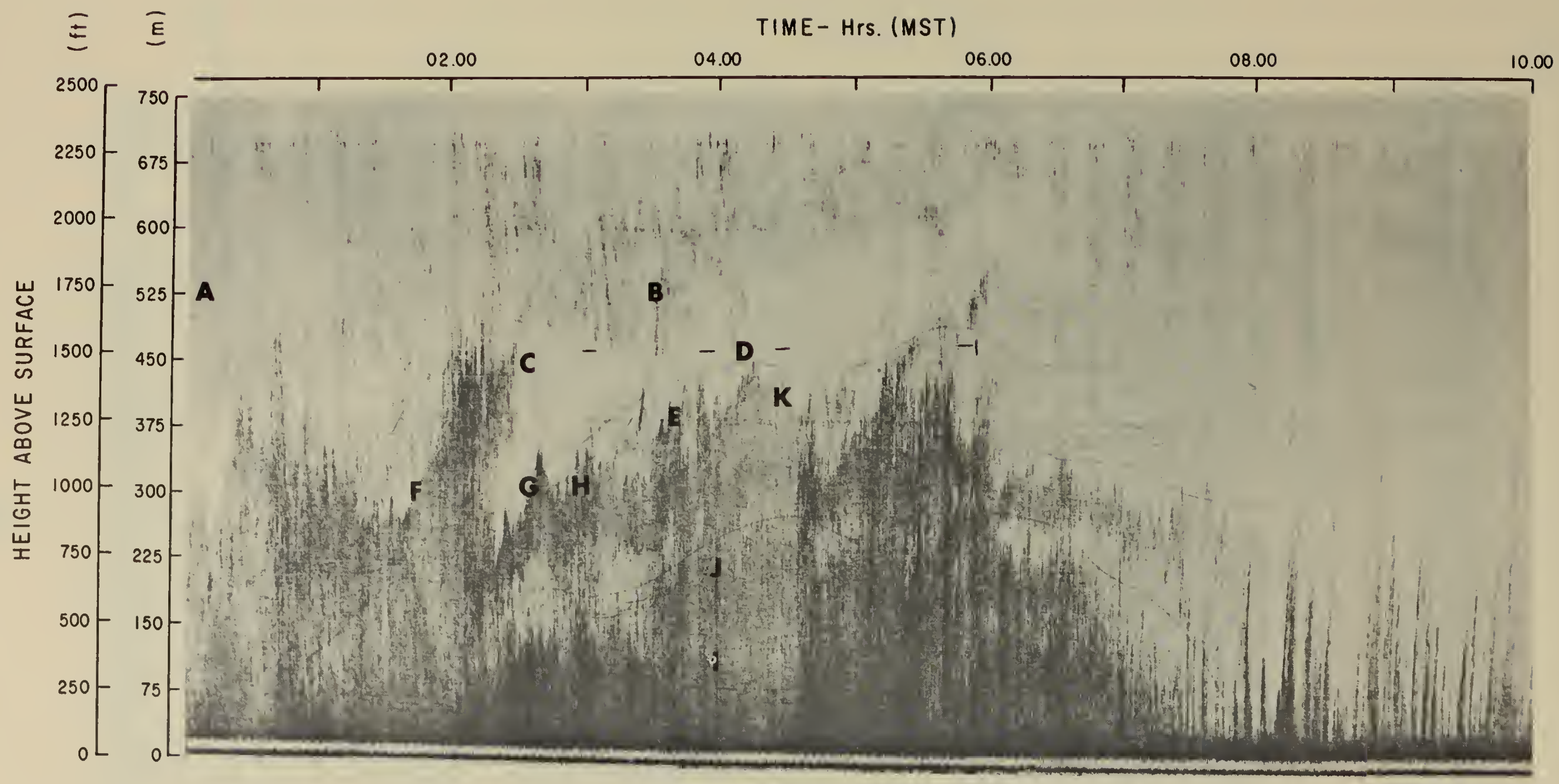
* 5 minute values at the beginning of each hour

B.1.2.1.2 Acoustic Sounder-Tethersonde Data

The height from which acoustic sounder returns are recorded in the surface-based cold air stratum should be a function of the depth of the stable air, its speed over the rough surface, and the roughness of the surface. It is quite possible that the surface-based layer may be too deep and stable for the effect of surface friction to be felt throughout its depth. It is also possible that this layer may be perturbed at its upper surface by the flow of the air high above the ground. When the down-slope flow is shallow (e.g., in the early evening), there may be no way to differentiate the cause of turbulence in that flow. Later, however, the cold, stable air may become so deep that disturbances from above do not cause turbulence in the stratum disturbed from below. Then an intermediate stratum could exist within the cold air in which turbulence is not strong enough to yield a return. Thus, it is readily conceivable that at least two bands of strong return may exist, separated by a band of weak return. Figure B-9 illustrates this.

During the period 0401 to 0437 MST, a time period centered at the event marked D in Figure B-9, the tethersonde sounding shown in Figure 3-6a was made at Station 020. That sounding also provided part of the data used to construct Figure 3-9. A comparison of the three figures is instructive. The tethersonde sounding reached its highest level at 0423 MST, about midway in time between events D and K in Figure B-9. The dark band generally found below 500 feet in the acoustic radar record corresponds closely with the down-canyon flow shown in Figures 3-6 and 3-7. Likewise, the light region shown above D and K on the radar record can readily be identified with the adiabatic stratum at the top of the tethersonde sounding. The acoustic returns immediately below D and K are coming from the top of the stable stratum which has its base at the ground. Figures 3-6 and 3-7 both show that the winds from the free atmosphere at higher levels are disturbing the top of this stable stratum, thereby creating the turbulence required to produce the temperature inhomogeneities upon which the radar return depends.

A third band of echoes formed at about 0315 MST between the two bands identified above. This band broadened rapidly and by 0415 MST a distinct third echo-rich stratum existed between 500 and 900 feet. The source of turbulent energy in this layer is not obvious, because at the time of the tethersonde sounding (Figure 3-6) the wind from 500 to 1000 feet was essentially calm. Figure 3-7 shows that air adjacent to the surface was flowing from Station 023 on the south side of the valley toward Station 020. It also shows that we should expect air to be flowing from the north side of the valley toward Station 020. Thus, at 0415 MST air in the 500-1000 foot stratum at Station 020 had been flowing over the rough surface north and south of the creek only a little while earlier. In the process, temperature inhomogeneities were created,



ACOUSTIC SOUNDER RECORD FOR THE PERIOD FROM 0000 TO 1000 HOURS MST, 24 JUNE 1976 AT STATION 020. REFERENCE TO THE LETTERS ON THE FIGURE ARE MADE IN THE TEXT (SEE TEXT). ALTERNATING DARK AND LIGHT VERTICAL BANDS ARE CAUSED BY FLUCTUATIONS IN LINE VOLTAGE.

FIGURE B-9

and it is probable that they continue to exist in adequate numbers and with adequate strength to produce the echoes in the intermediate layer seen in Figure B-9.

B.1.2.1.3 Aircraft and Acoustic-Sounder Data

Aircraft soundings were made on fifteen days in the fall of 1974 and during each of the first three quarters of 1975. These were used as shown in Figure B-10 to determine the bases and tops of inversions. The data are summarized in Tables B-12 and B-13. Bullard and Fosdick (1976) compared these data with concurrent "inversion data" read from the records of the acoustic-sounder located at Station 023. The results are summarized in Table B-14. Marlatt Assoicates selected occurrences and heights of inversions from the acoustic-sounder data; EG&G selected occurrences and heights from aircraft soundings. The criteria used by EG&G included a requirement that an inversion be at least 200 feet deep and that the top of the inversion stratum be at least 1^0C warmer than the base. The acoustic-sounder will detect strata which are thinner than 200 feet, and it will detect potential temperature (Θ) inversions as well as temperature (T) inversions if sufficient turbulence is present in the inversion stratum. Hence, it is not surprising that numerous "inversions" were selected by Marlatt Associates which were not chosen by EG&G. On the other hand, a strong inversion in which there was insufficient turbulence, would go undetected by the acoustic-sounder. There may have been a few of these. If the aircraft soundings had been plotted on pressure (height) vs potential temperature diagrams and inversions of 1^0C of potential temperature per 200 feet had been used as the criteria for selecting an inversion, there would have been fewer disagreements on inversions Marlatt Associates recorded. There would probably have been more disagreements on the inversions EG&G recorded. What might have happened to the number of disagreements on inversion height is unpredictable.

Acoustic-sounder theory and careful observation have shown that when a properly operating sounder shows an echo which has good horizontal continuity, the stratum from which that echo comes is stable (i.e., it is a stratum in which the potential temperature increases with height) and it is or has recently been turbulent. The turbulence cannot have been strong enough to mix the stratum thoroughly in the vertical, however, because thorough vertical mixing would destroy the potential temperature inversion. Therefore, any "inversions" observed by means of the acoustic-sounder should be viewed as effective dampers of vertical mixing for as long as they endure. The turbulence in them does provide a mechanism for slow vertical mixing; unfortunately no present sounding technique yields a satisfactory quantitative measure of the rate of vertical mixing which should occur in a stable layer.

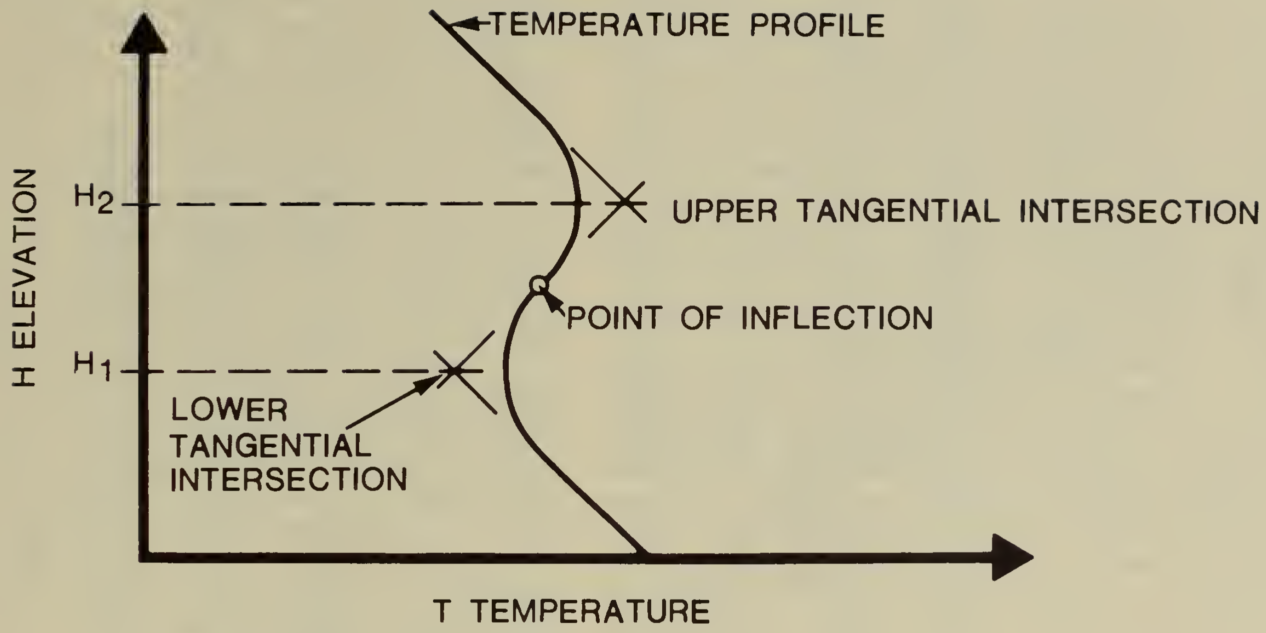


FIGURE B-10

DETAILED TEMPERATURE PROFILE (IDEALIZED INVERSION)

Table B-12 FALL/WINTER H_1 - H_2 DATA FROM AIRCRAFT

FALL, 1974

DATE		Sounding #1	#2	#3	#4
October 1, 1974	h_1	--	--	--	--
	h_2	--	350	--	--
October 2, 1974	h_1	--	--	--	--
	h_2	500	100	--	--
October 3, 1974	h_1	--	--	--	msg
	h_2	800	500	--	msg
October 7, 1974	h_1	--	--	--	--
	h_2	--	600	--	--
October 8, 1974	h_1	--	--	--	--
	h_2	--	750	--	msg
October 9, 1974	h_1	--	--	--	--
	h_2	1300	--	--	--
October 10, 1974	h_1	--	--	--	--
	h_2	350	450	--	--
October 11, 1974	h_1	--	--	msg	msg
	h_2	1000	100	msg	msg
October 13, 1974	h_1	msg	msg	4800	--
	h_2	msg	msg	4900	--
October 14, 1974	h_1	--	1000	--	--
	h_2	--	1800	--	--
October 15, 1974	h_1	--	--	--	--
	h_2	--	600	-600	--

WINTER, 1975

DATE		Sounding #1	#2	#3	#4
January 20, 1975	h_1	msg	1200	--	--
	h_2	msg	1600	-500	800
January 23, 1975	h_1	--	-500	--	--
	h_2	1700	1500	--	--
January 24, 1975	h_1	2600	--	--	--
	h_2	2900	100	-400	--
January 25, 1975	h_1	msg	--	4300	--
	h_2	msg	--	4600	--
January 26, 1975	h_1	1900	750	1600	--
	h_2	2400	2100	2100	--
January 29, 1975	h_1	--	--	3800	--
	h_2	--	150	4200	--
January 31, 1975	h_1	msg	msg	--	--
	h_2	msg	msg	--	--
February 1, 1975	h_1	msg	--	--	--
	h_2	msg	-200	--	--
February 2, 1975	h_1	2600	--	--	--
	h_2	3000	200	-500	--
February 3, 1975	h_1	--	--	--	--
	h_2	--	200	100	--
February 4, 1975	h_1	--	--	--	msg
	h_2	--	--	--	msg
February 6, 1975	h_1	--	--	-600	--
	h_2	900	800	50	--
February 7, 1975	h_1	msg	msg	--	--
	h_2	msg	msg	--	--
February 8, 1975	h_1	--	--	--	--
	h_2	--	--	--	--
February 9, 1975	h_1	--	--	msg	msg
	h_2	--	--	msg	msg

msg - indicates that sounding was not made

-- - indicates that H_1 or H_2 was undefined

Table B-13 SPRING/SUMMER H_1 - H_2 DATA FROM AIRCRAFT

SPRING, 1975

DATE		Sounding #1	#2	#3	#4
April 14, 1975	h_1	--	--	--	--
	h_2	--	--	--	--
April 15, 1975	h_1	--	--	--	--
	h_2	--	--	--	--
April 16, 1975	h_1	--	--	--	msg
	h_2	--	--	--	msg
April 18, 1975	h_1	msg	msg	--	--
	h_2	msg	msg	--	--
April 19, 1975	h_1	5500	5400	500	--
	h_2	5800	--	--	--
April 20, 1975	h_1	--	--	--	--
	h_2	200	00	--	--
April 21, 1975	h_1	--	--	--	--
	h_2	1600	--	--	--
April 22, 1975	h_1	--	--	--	--
	h_2	200	--	--	--
April 23, 1975	h_1	--	--	--	--
	h_2	100	--	--	--
April 24, 1975	h_1	--	2900	--	--
	h_2	00	3150	--	--
April 25, 1975	h_1	--	3500	msg	msg
	h_2	--	3950	msg	msg
April 28, 1975	h_1	--	--	--	msg
	h_2	-50	--	--	msg
April 29, 1975	h_1	--	--	--	--
	h_2	--	--	--	--
April 30, 1975	h_1	--	--	--	--
	h_2	--	--	--	msg
May 1, 1975	h_1	--	--	--	msg
	h_2	400	-100	--	msg

SUMMER, 1975

DATE		Sounding #1	#2	#3	#4
July 12, 1975	h_1	--	--	--	--
	h_2	500	--	--	--
July 13, 1975	h_1	--	--	--	--
	h_2	100	--	--	--
July 14, 1975	h_1	--	--	--	--
	h_2	200	--	--	--
July 15, 1975	h_1	--	--	--	--
	h_2	200	--	--	--
July 16, 1975	h_1	--	--	msg	msg
	h_2	-150	--	msg	msg
July 17, 1975	h_1	-50	--	--	--
	h_2	00	-450	--	--
July 18, 1975	h_1	--	--	--	--
	h_2	1050	--	--	--
July 19, 1975	h_1	--	--	--	msg
	h_2	1100	--	--	msg
July 20, 1975	h_1	--	--	--	--
	h_2	800	--	--	--
July 21, 1975	h_1	--	--	--	--
	h_2	-100	-350	--	--
July 22, 1975	h_1	--	--	--	--
	h_2	800	--	--	--
July 23, 1975	h_1	--	--	--	--
	h_2	800	--	--	--
July 24, 1975	h_1	--	--	--	--
	h_2	1000	--	--	--
July 25, 1975	h_1	--	--	--	--
	h_2	1000	--	--	--
July 26, 1976	h_1	--	--	--	msg
	h_2	1050	00	--	msg

msg - indicates that sounding was not made

-- - indicates that H_1 or H_2 was undefined

Table B-14

COMPARISON OF PUBLISHED AIRCRAFT AND ACOUSTIC SOUNDER INVERSION DATA

CLASS	JAN. FEB. 1975	APRIL MAY 1975	JULY 1975	TOTAL	TOTAL PERCENT
1. Agree No Inversion	24	30	26	80	64.5
2. Agree Inversion ± 250 ft.	6	2	4	12	9.7
3. Disagree On Inversion Height	5	1	0	6	4.8
4. Disagree on Inversion Marlatt Records	12	6	1	19	15.3
5. Disagree on Inversion EG&G Records	3	0	4	7	5.6
Total Comparisons	50	39	35	124	99.9

The aircraft soundings, having been conducted through all four seasons, provided useful insights to both temperature and flow fields in the Piceance Valley. Figures B-11, 3-10, B-12, and B-13 show typical sounding sequences from fall, winter, spring, and summer, respectively. The sequences were surprisingly similar, and they were quite similar to sounding sequences (Figure 3-6) taken with the tethersonde.

Horizontal lines have been drawn at the height of Station 023 (6970 feet), the height of the top of the tower (7170 feet), the height of the ridge across Piceance Creek north of the C-b Tract (7400 feet), and the height of the ridge surrounding the valley on the west, south, and east (8200 feet). Isotherms of potential temperature (adiabats) are also shown -- the slanting dashed lines.

The nighttime soundings showed that in every case the valley filled to the level of the 8200-foot ridge with cold, stable air. From surface and tower wind data it is virtually certain that the cold air near the surface was flowing down the valley slopes toward the creeks and then down the creek. The tethersonde data have shown that this flow is much deeper than the height of the tower. The tethersonde data have also shown that the wind at the level of the tops of the surrounding ridges is strongly influenced by the flow of the free air at even higher levels. Between this free air flow and the valley flow is a buffer zone in which winds may be affected alternately by the higher and lower flow regimes. The air in this intermediate zone is stable and waves akin to water waves form in it. These may change the stability of the stratum rapidly, but as long as the cold valley floor and walls provide a good strong source of cold air below, such changes will be short-lived. There will virtually always be an acoustic radar echo from this stratum, and at night vertical mixing everywhere in or below it will be severely restricted.

Figures B-12 and B-14 are used to show how aircraft and acoustic-sounder records may be compared. Such comparisons yield useful information about the interpretation of both. Three of the aircraft soundings were made at times which are covered by the portion of acoustic-sounder record shown as Figure B-14. The sounding at 1128 MST can be interpreted with the least effort. The aircraft sounding was adiabatic within the accuracy of the data from 7000 feet to 10,000 feet. There was undoubtedly a shallow superadiabatic layer at the ground from which convective activity was carrying heat upward since nearly uniform warming occurred throughout a deep layer (at least up to 13,000 feet) between 1128 and 1738 MST. At 1128 MST then, one would expect the acoustic record to show numerous vertical spikes near the surface and little if any echo between the tops of those spikes and at least 12,000 feet where a small potential temperature inversion occurs. The record bore this out.

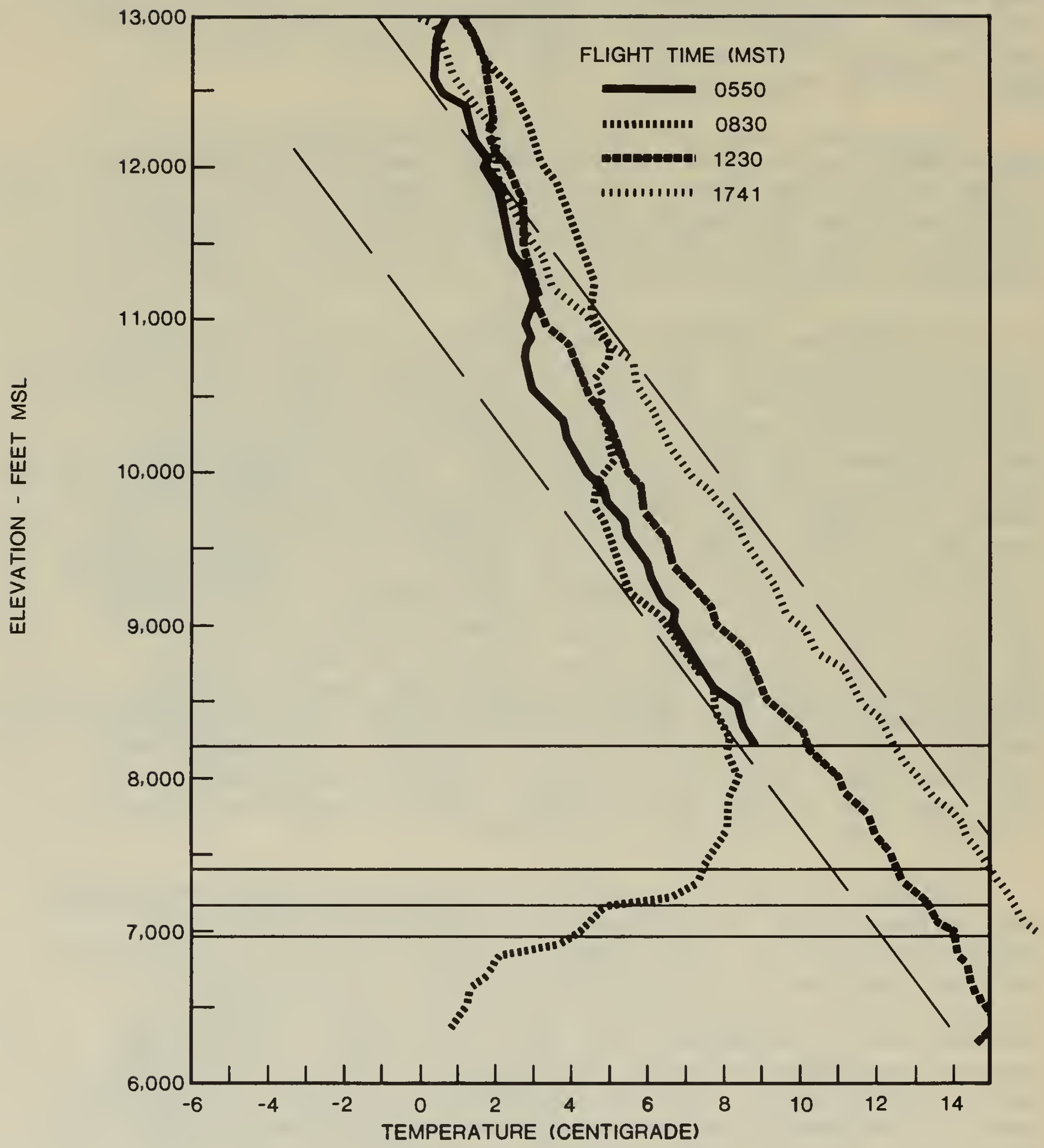


FIGURE B-11 TEMPERATURE SOUNDINGS OVER TRACT C-b BY AIRCRAFT ON 15 OCTOBER 1974

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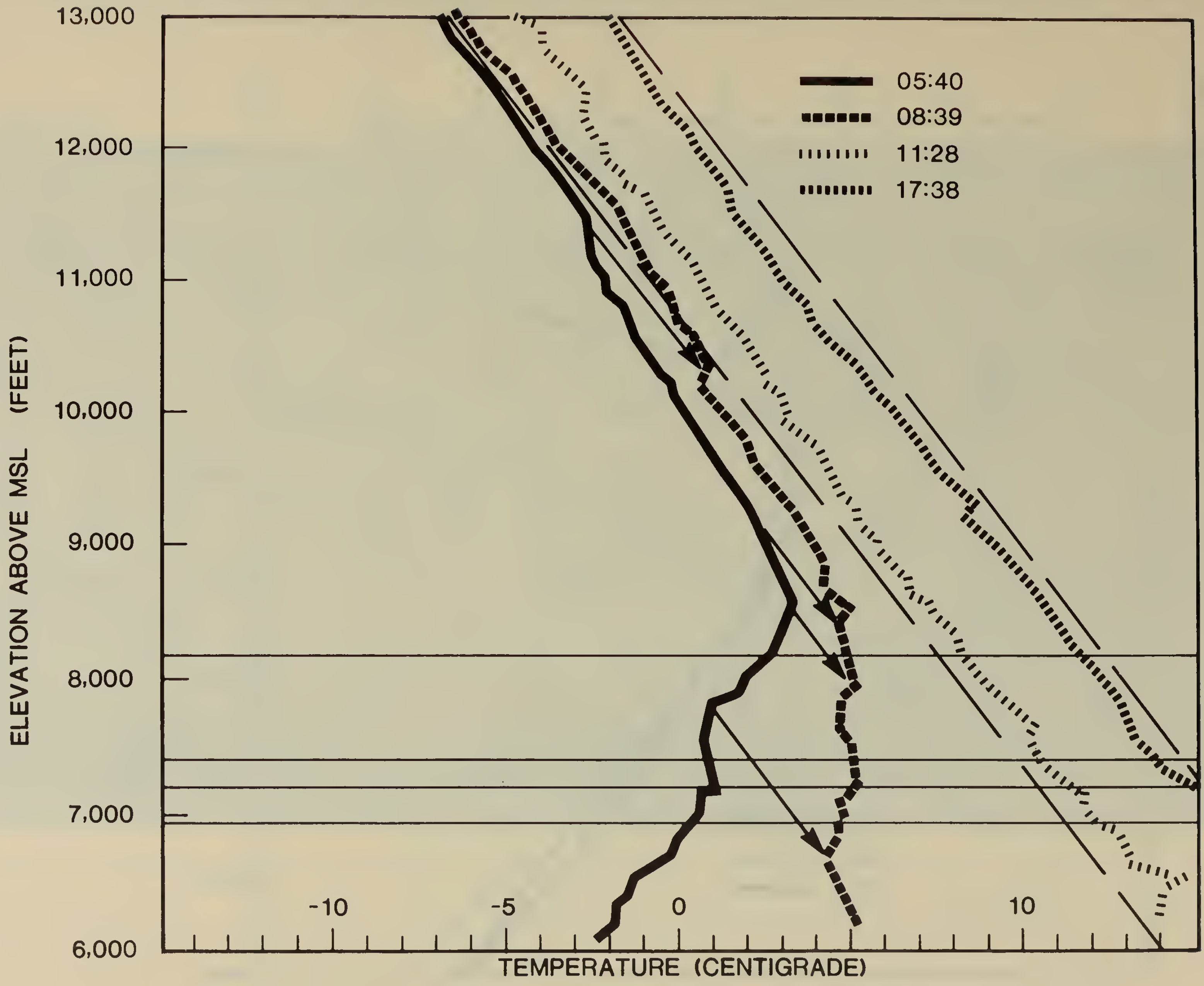


FIGURE B-12 TEMPERATURE SOUNDINGS OVER TRACT C-b BY AIRCRAFT ON APRIL 21, 1975

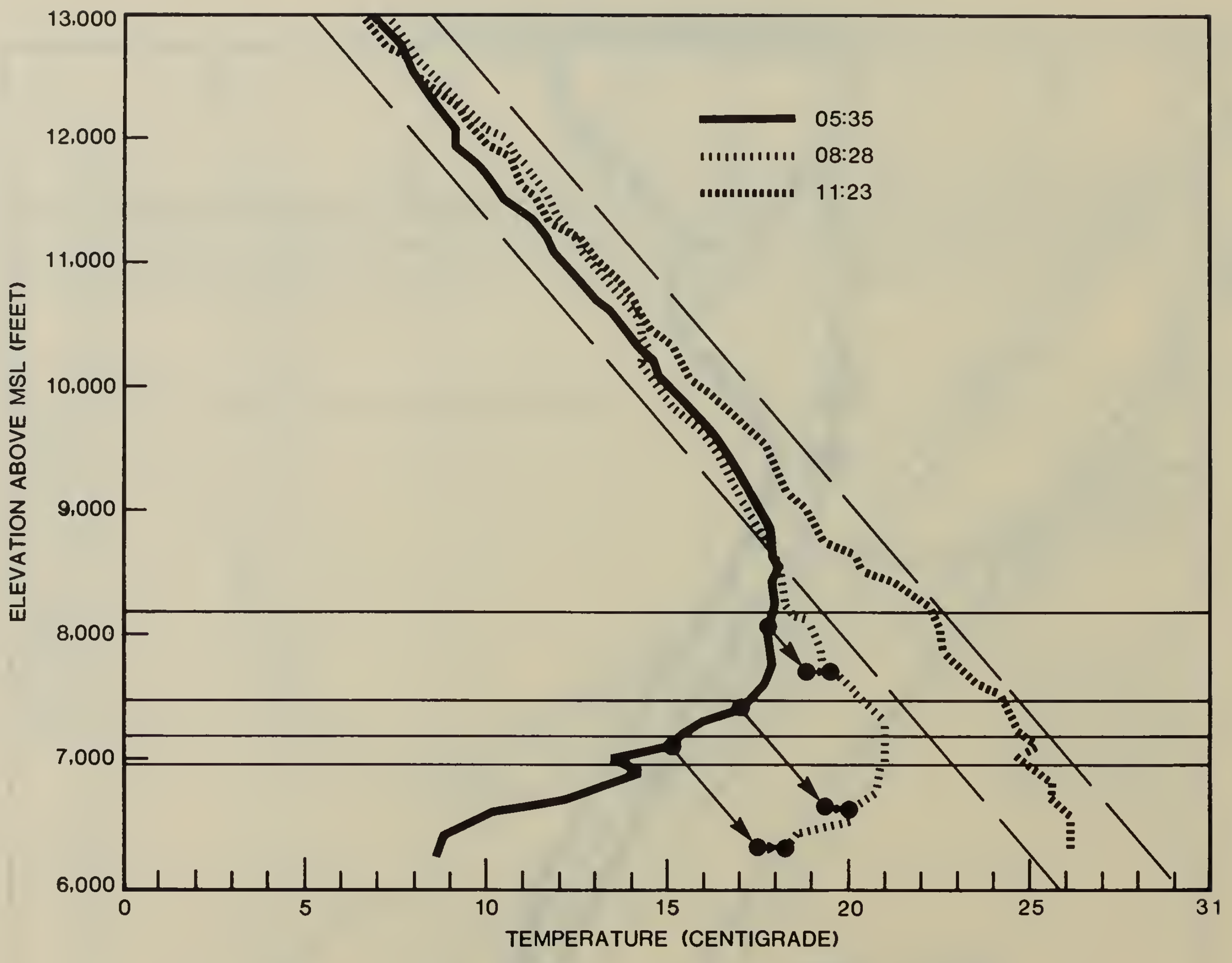


FIGURE B-13 TEMPERATURE SOUNDINGS OVER TRACT C-b BY AIRCRAFT ON JULY 16, 1975

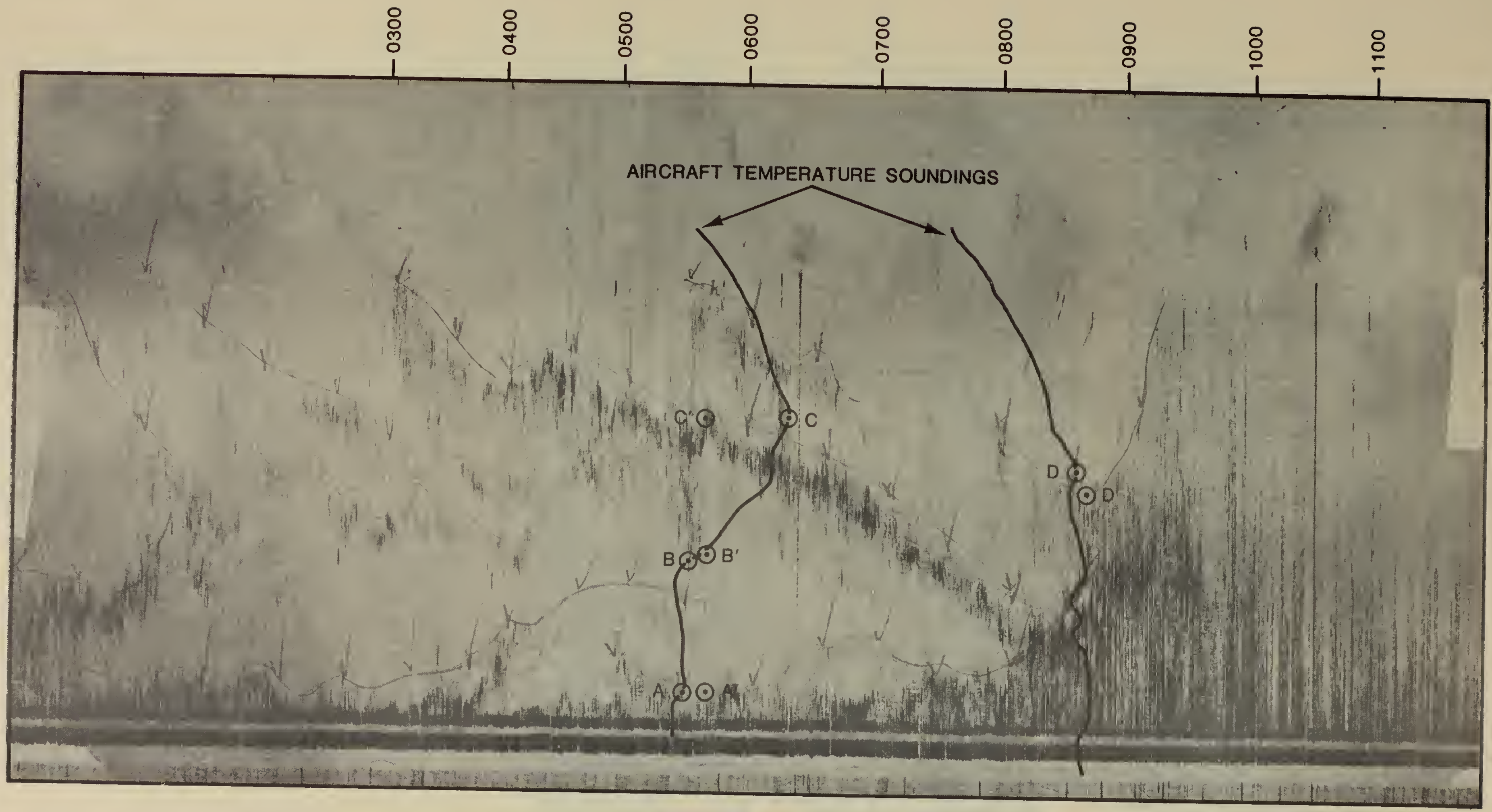


FIGURE B-14 COMPOSITE OF ACOUSTIC SOUNDER RECORD AND AIRCRAFT SOUNDINGS FROM FIGURE B-12

In contrast, the sounding at 0540 MST showed three distinct strata which were returning echoes. The echoes near the surface were from the stable cold air in the valley which was being disturbed by flow over the rough surface. The echoes in the stratum immediately below 8500 feet were from the top of the cold valley air where it was perturbed by the free air flow above. Another echoing stratum with its top at 9100 feet was caused by mixing of the cold air up into the free flow above. When the interaction between the free flow and cold air was particularly active, echoes appeared. When the interaction was less active, the echoes faded away, so that this echo stratum was not as persistent as the one below.

By the time of the 0839 MST sounding, the subsiding cold air had become so shallow that the echoes in its top had merged with those at its base. There was still a stratum above, as high as 8200 feet, from which echoes were coming. The aircraft sounding showed evidence of a disturbance (a shallow superadiabatic layer) at 8500 feet which was only slightly higher than the highest acoustic echo at that time. Note also, that if the cold air were subsiding adiabatically from the 0540 to 0830 MST soundings as indicated by the arrows in Figure B-12, the descent of air parcels was nearly identical with the descent of the echoing strata in Figure B-14.

The acoustic sounder showed evidence of convective mixing near the ground at 0839 MST. Tall convective plumes developed rapidly thereafter and by 0930 MST extended above 9000 feet. Only as long as these convective plumes penetrated into the more stable air aloft were they visible as echoes at high levels. By about 1000 MST they have mixed the air so completely that it has become adiabatic everywhere except near the surface, where it was superadiabatic. The lapse rate from 1000 to 1738 MST was almost surely well mixed at all levels reached by the acoustic sounder.

B.1.3 Other Meteorological Parameters

These data support Section 3.1.3.

B.1.3.1 Solar Radiation

Table B-15 gives total solar radiation for each month (langleys) at Station 023 modified to include the effects of missing data and unmodified, daily average for the month, and both highest and lowest daily totals with the associated date. Figure B-15 is a two-year time series of daily total solar radiation.

B.1.3.2 Relative Humidity

Tables B-16 (a through h) present average relative humidity for each month and the date and level of the extrema. Figures B-16 a and b show the seasonal variations in the daily mean and daily extrema.

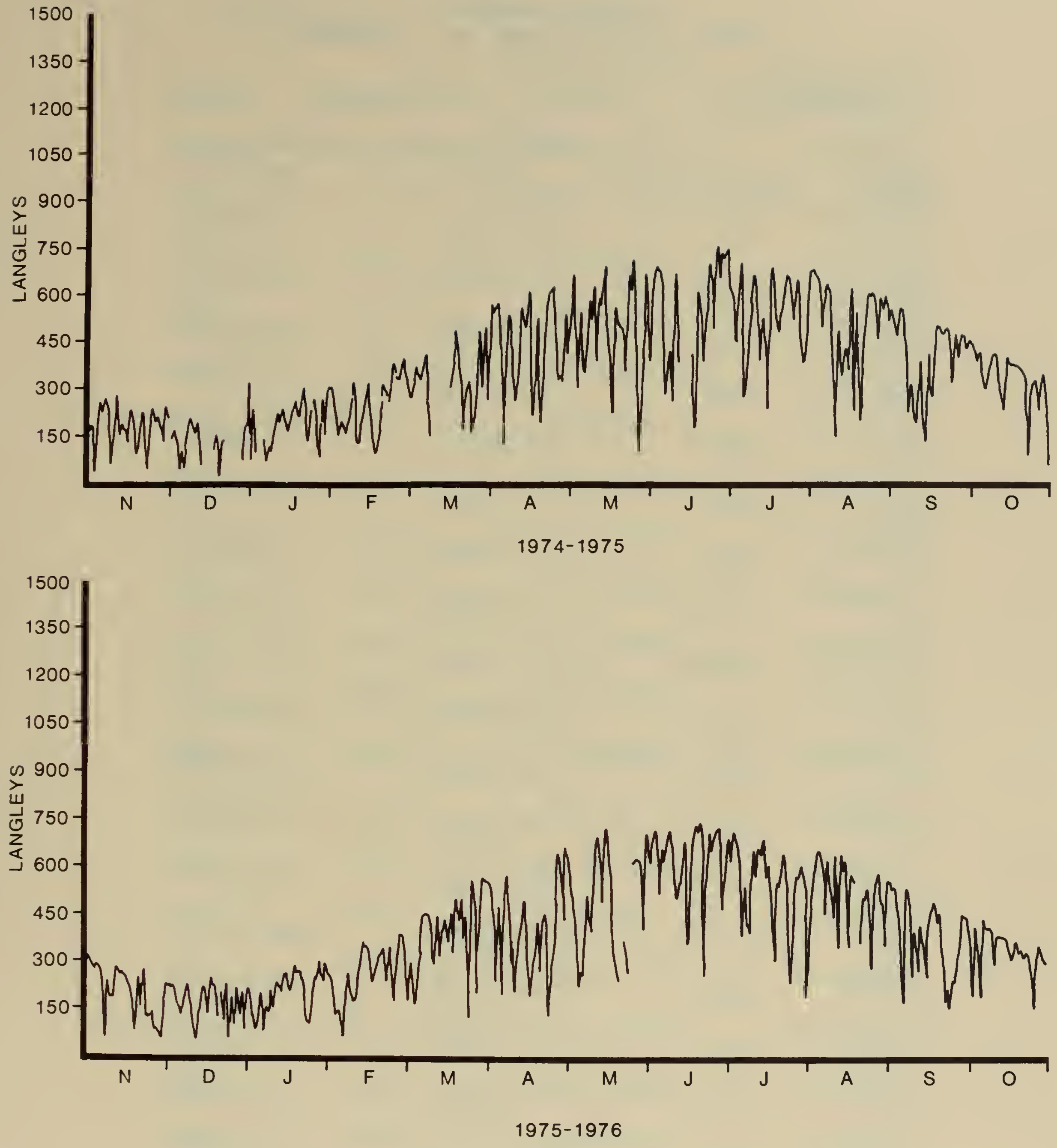
B.1.3.3 Barometric Pressure

Table B-17 gives the average and the extrema of daily averages for each month at Stations 023 and 024.

Table B-15
SOLAR RADIATION
STATION 023

MONTH	TOTAL LANGLEYS (MODIFIED)	TOTAL LANGLEYS (UNMODIFIED)	DAILY AVE. (LANGLEYS) (MODIFIED)	DAILY AVE. (LANGLEYS) (UNMODIFIED)	HIGHEST DAILY TOTAL/DATE	LOWEST DAILY TOTAL/DATE
11/74	4,256	4,121	141.9	137.4	225/11	1/3
12/74	3,500	1,878	112.9	60.6	164/9	0/7
1/75	4,396	4,036	141.8	130.2	266/1	22/28
2/75	7,305	6,880	260.9	245.7	416/24	100/15
3/75	10,076	7,586	325.0	244.7	479/19	142/9
4/75	11,325	10,940	377.5	364.7	550/25	65/7
5/75	14,559	14,559	469.6	469.6	706/26	94/28
6/75	15,667	13,762	522.2	458.7	737/26	166/18
7/75	16,659	16,079	537.4	518.7	687/6	227/16
8/75	15,870	15,005	511.9	484.0	665/3	324/13
9/75	12,324	11,849	410.8	395.0	545/6	180/11
10/75	10,114	10,089	326.3	325.5	446/1	28/31
11/75	4,670	4,615	155.7	153.8	279/1	11/28
12/75	4,007	3,957	129.3	127.6	207/18	13/25
1/76	6,176	6,166	199.2	198.9	303/29	85/5
2/76	8,102	8,102	279.4	279.4	393/22	59/6
3/76	12,046	11,856	388.6	382.5	567/30	133/25**
4/76	13,225	11,990	440.8	399.7	656/28	187/17
5/76	15,198	14,693	490.3	474.0	732/16	224/6
6/76	18,689	18,674	623.0	622.5	741/21	277/22**
7/76	17,292	17,102	557.8	551.7	720/4	229/5
8/76	15,961	15,351	514.9	495.2	665/5	193/1
9/76	11,477	11,477	382.6	382.6	558/2	155/24
10/76	10,178	10,178	328.3	328.3	440/7	143/26

** Estimated total



STATION 023
TWO ANNUAL TIME SERIES
OF DAILY TOTAL SOLAR RADIATION

FIGURE B-15

Table B-16

RELATIVE HUMIDITY -
MONTHLY AVERAGES AND DAILY EXTREMA

a. Station 020

Month	Average (%)	Highest Daily/ Date	Lowest Daily/ Date
11/74	66.0	95.0/9th	38.9/21st
12/74	71.9*	91.2*/29th	44.4*/3rd
1/75	65.9	89.9/30th	42.8/15th
2/75	64.9	92.7/14th	43.1/7th
3/75	63.9	85.9/10th	44.5/20th
4/75	56.3	89.4/1st	24.7/25th
5/75	54.0	91.8/28th	27.8/4th
6/75	46.6*	79.9/10th	21.9/25th
7/75	48.6*	64.8/30th	24.0/1st
8/75	39.0	67.0/21st	23.7/31st
9/75	41.1	73.3/12th	22.8/25th
10/75	46.7	96.5/23rd	21.8/2nd
11/75	60.7*	92.8/8th	29.5/17th
12/75	73.4*	90.6/31st	48.2/1st
1/76	69.8*	86.8/6th	52.7/8th
2/76	63.2	85.7/6th	37.0/23rd
3/76	60.8	88.2/4th	31.9/23rd
4/76	53.7	89.4/18th	32.1/1st
5/76	51.6*	74.7/20th	27.5/3rd
6/76	39.3	74.7/17th	25.6/10th
7/76	41.3*	72.9/18th	22.9/5th
8/76	43.5	75.4/1st	24.2/15th
9/76	54.0	86.8/25th	22.9/4th
10/76	47.1	73.4/26th	27.3/22nd

*Significant Downtime to Possibly Affect Totals

Table B-16

b. Station 021

Month	Average (%)	Highest Daily/ Date	Lowest Daily/ Date
11/74	62.6	83.2/3rd	43.6/21st
12/74	74.4*	94.8/29th	49.3/4th
1/75	74.7	96.7/10th	44.7/15th
2/75	73.0	99.9/14th	49.5/13th
3/75	70.3	91.6/10th	51.7/5th
4/75	64.6	93.9/1st	37.2/6th
5/75	58.4	95.0/28th	29.5/4th
6/75	53.2	87.7/8th	25.1/29th
7/75	55.8	75.1/9th	28.8/1st
8/75	42.8	71.9/13th	23.7/31st
9/75	48.9	90.2/11th	25.5/1st
10/75	55.1*	100.0/23rd	26.0/2nd
11/75	70.5	95.8/8th	47.8/6th
12/75	80.8	96.0/31st	54.8/1st
1/76	78.1	92.7/4th	56.5/8th,9th
2/76	70.5	90.1/5th	45.1/29th
3/76	67.0	92.3/4th	38.0/23rd
4/76	59.5	95.1/18th	37.5/1st
5/76	59.9	89.4/8th	35.5/3rd
6/76	44.4	80.5/17th	30.6/10th
7/76	46.3	83.0/18th	26.9/5th
8/76	49.1	81.2/1st	29.0/15th
9/76	59.5	91.7/25th	26.5/4th
10/76	52.9	80.9/26th	29.2/11th

*Significant Downtime to Possibly Affect Totals.

Table B-16

c. Station 022

Month	Average (%)	Highest Daily/ Date	Lowest Daily/ Date
11/74	69.9	97.9/9th	44.4/21st
12/74	74.1	94.0/7th	47.1/3rd
1/75	71.1	95.3/30th	46.7/13th
2/75	70.9	98.2/14th	51.6/7th
3/75	69.6	91.2/10th	49.4/20th
4/75	60.7	92.7/1st	26.9/5th
5/75	58.4	97.1/28th	31.8/4th
6/75	58.5*	86.3/10th	40.3/17th
7/75	57.0*	84.9/14th	43.8/25th
8/75	44.1	79.4/13th	25.3/31st
9/75	45.2*	81.0/12th	26.0/25th
10/75	48.7	97.7/23rd	24.5/11th
11/75	66.1*	96.3/8th	42.4/16th
12/75	77.3	91.7/25th	54.6/1st
1/76	73.9	91.6/6th	59.9/8th
2/76	67.4	96.0/6th	36.2/23rd
3/76	64.3*	91.5/4th	38.6/23rd
4/76	57.8	94.9/17th	36.1/11th
5/76	51.6*	90.5/8th	29.1/3rd
6/76	42.4*	78.4/17th	28.9/10th
7/76	42.1*	67.0/26th	24.9/5th
8/76	43.9*	69.1/2nd	27.0/15th
9/76	56.6*	88.6/24th	23.4/4th
10/76	54.0*	76.9/26th	30.1/10th

*Significant Downtime to Possibly Affect Totals.

Table B-16

d. Station 023-8'

Month	Average (%)	Highest Daily/ Date	Lowest Daily/ Date
11/74	63.6	95.3/3rd & 9th	33.3/21st
12/74	67.3*	90.5*/30th	35.4*/3rd
1/75	68.5*	100*/30th	37.0*/15th
2/75	75.3	100/15th	54.2/3rd
3/75	74.6*	96.1*/26th	54.7*/5th
4/75	69.5	100.0/1st	39.6/5th
5/75	67.3	100.0/28th	41.0/4th
6/75	68.8*	99.0/8th	46.4/17th
7/75	-	-	-
8/75	32.8*	61.6/13th	19.4/4th
9/75	38.8*	84.7/11th	22.3/25th
10/75	42.6	92.1/31st	23.2/2nd
11/75	53.4	93.7/8th	23.9/17th
12/75	62.8*	82.6/14th	48.7/4th
1/76	61.4	81.0/1st	35.4/22nd
2/76	57.4	81.4/20th	28.6/23rd
3/76	55.7	85.0/4th	29.8/23rd
4/76	51.6*	88.6/18th	28.3/1st
5/76	50.8*	80.3/8th	28.3/2nd
6/76	42.9	78.2/17th	30.1/4th
7/76	45.6	75.6/18th	31.1/4th
8/76	47.8	77.3/1st	32.6/6th
9/76	56.4	85.3/24th	32.4/4th
10/76	47.9	72.9/3rd	32.2/10th

*Significant Downtime to Possibly Affect Totals.

Table B-16

e. Station 023-30'

Month	Average (%)	Highest Daily/ Date	Lowest Daily/ Date
11/74	62.8	99.7/3rd	34.1/21st
12/74	69.3*	97.1*/7th	35.3*/3rd
1/75	68.3*	96.6*/30th	34.3/15th
2/75	72.0	100/15th	48.4/26th
3/75	72.2*	95.6*/26th	53.6*/5th
4/75	67.3	99.5/1st	38.1/22nd
5/75	63.9*	100.0/28th	40.8/4th
6/75	-	-	-
7/75	-	-	-
8/75	28.8*	56.2/12th	15.9/4th
9/75	35.3*	84.7/11th	19.2/25th
10/75	39.9	91.9/31st	19.9/2nd
11/75	53.1	95.3/8th	22.0/17th
12/75	62.3	84.9/14th	47.3/4th
1/76	61.7	86.1/1st	33.9/22nd
2/76	57.2	84.7/20th	27.5/23rd
3/76	55.9	88.6/4th	29.1/23rd
4/76	52.5*	91.4/18th	28.7/1st
5/76	50.6*	80.5/8th	28.4/2nd
6/76	43.7	80.5/17th	30.3/4th
7/76	46.9	79.5/18th	31.9/5th
8/76	50.1	78.9/1st	34.8/6th
9/76	59.0	89.3/24th	32.4/4th
10/76	50.7	77.2/3rd	35.6/10th

*Significant Downtime to Possibly Affect Totals.

Table B-16

f. Station 023-100'

Month	Average (%)	Highest Daily/ Date	Lowest Daily/ Date
11/74	61.4	99.6/3rd	33.7/21st
12/74	68.7*	95.0/31st	34.3/3rd
1/75	67.4*	99.8/30th	33.8/15th
2/75	73.6	100/15th	50.7/26th
3/75	73.9*	96.2*/26th	55.9*/19th
4/75	68.5	99.8/1st	39.4/5th
5/75	64.8	100.0/28th	41.7/26th
6/75	54.4*	89.8/10th	29.7/29th
7/75	54.2*	91.2/16th	30.8/1st
8/75	-	-	-
9/75	-	-	-
10/75	-	-	-
11/75	56.7	99.3/8th	22.2/17th
12/75	67.6*	95.8/14th	49.4/4th
1/76	64.5	89.7/1st	34.5/22nd
2/76	59.4	92.2/6th	28.8/23rd
3/76	58.9	96.4/4th	30.2/23rd
4/76	55.3*	97.0/18th	29.0/1st
5/76	52.1*	86.2/8th	28.4/3rd
6/76	43.4	84.0/17th	28.8/4th
7/76	44.5	79.0/18th	29.0/5th
8/76	47.7	77.0/1st	31.7/6th
9/76	58.3	91.0/24th	31.4/4th
10/76	50.9	78.1/3rd	33.6/10th

*Significant Downtime to Possibly Affect Totals.

Table B-16

g. Station 023-200'

Month	Average (%)	Highest Daily/ Date	Lowest Daily/ Date
11/74	63.1	100/3rd	35.7/21st
12/74	71.6*	100/7th	36.2/2nd
1/75	68.0*	99.4/30th	35.7/15th
2/75	71.2	100/15th	47.2/26th
3/75	71.2*	94.8/26th	52.4/19th
4/75	65.6	99.6/1st	35.7/5th
5/75	62.8	100/28th	37.9/4th
6/75	65.3*	93.7/8th	45.7/6th
7/75	-	-	-
8/75	30.2	55.1/21st	18.1/4th
9/75	37.2*	90.9/11th	21.2/25th
10/75	41.2	91.7/31st	22.8/2nd
11/75	54.6	98.4/8th	24.2/17th
12/75	-	-	-
1/76	61.2*	82.4/19th	34.3/22nd
2/76	59.2	92.0/6th	27.7/23rd
3/76	58.5	97.1/4th	29.7/23rd
4/76	55.4*	96.6/18th	29.7/1st
5/76	52.9*	88.4/8th	28.3/2nd
6/76	43.7	83.3/17th	29.5/4th
7/76	44.6	78.5/18th	30.3/4th
8/76	47.5	78.5/1st	30.7/6th
9/76	57.7	89.9/24th	30.9/4th
10/76	50.2	76.6/3rd,26th	33.9/10th

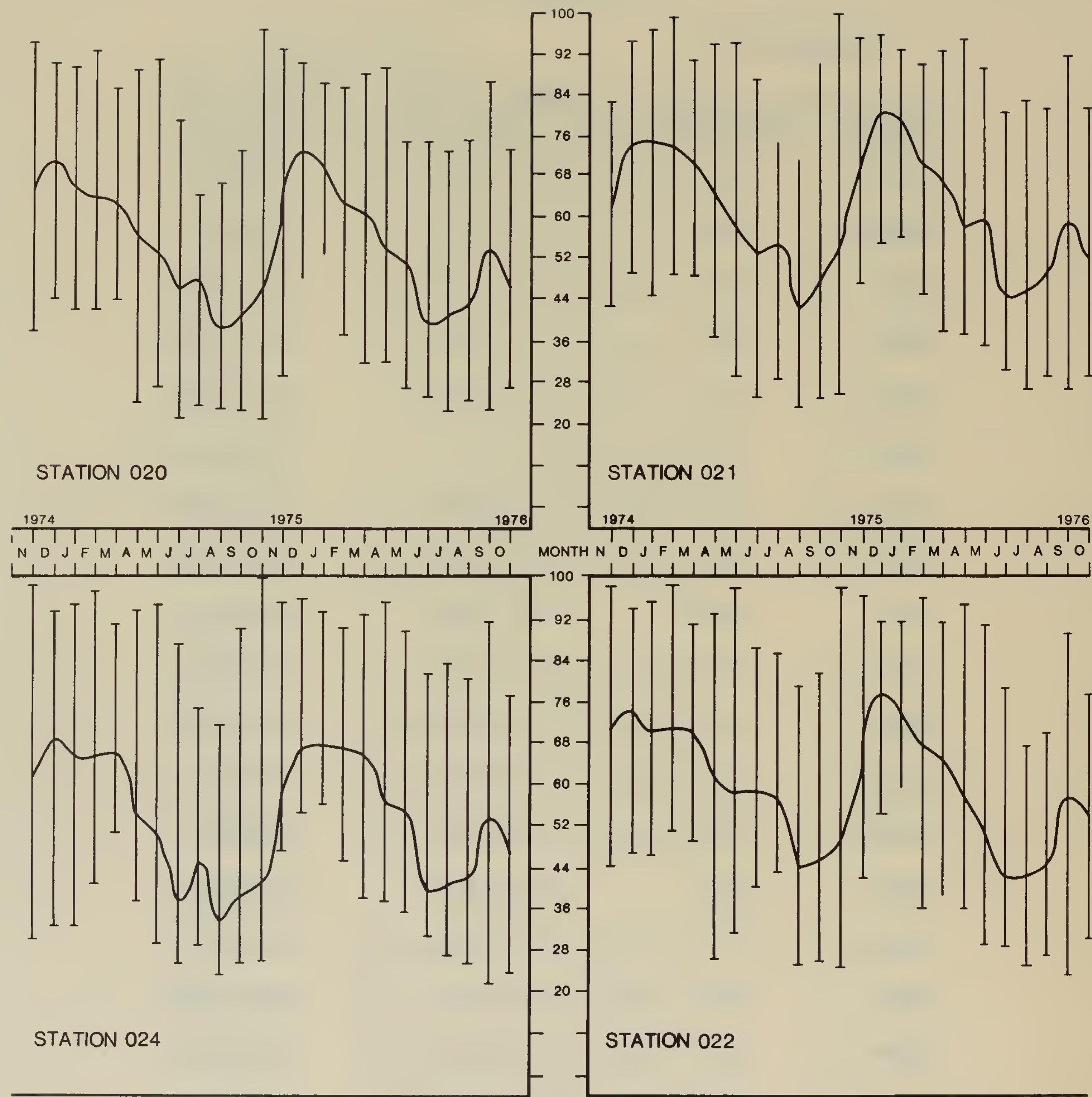
*Significant Downtime Possibly to Affect Totals.

Table B-16

h. Station 024

Month	Average (%)	Highest Daily/ Date	Lowest Daily/ Date
11/74	61.6	98.3/3rd	29.9/21st
12/74	68.6	93.5/7th	32.2/3rd
1/75	65.1	94.8/30th	32.3/15th
2/75	65.6	97.3/14th	41.6/13th
3/75	65.7	90.0/10th	43.5/20th
4/75	54.6*	94.2/1st	22.4/5th,6th
5/75	50.7*	95.8/28th	24.3/15th
6/75	37.8*	63.6/20th	14.9/30th
7/75	44.5*	76.7/16th	15.1/1st
8/75	33.7*	65.3/13th	19.2/31st
9/75	38.3	85.6/11th	19.4/25th
10/75	40.7	97.4/23rd	19.7/4th
11/75	57.5*	93.4/8th	28.5/6th
12/75	66.9	92.7/31st	51.7/4th
1/76	67.2	87.7/25th	41.8/22nd
2/76	66.6	96.0/6th	36.2/23rd
3/76	65.3	97.5/4th	33.3/23rd
4/76	56.2	95.8/17th	28.7/2nd
5/76	54.3*	90.0/8th	26.3/3rd
6/76	39.4	82.8/17th	21.1/29th
7/76	40.2	79.4/18th	20.2/5th
8/76	41.3*	80.0/1st	24.8/6th
9/76	53.7	91.4/24th	20.7/4th
10/76	44.1	76.4/26th	23.4/10th

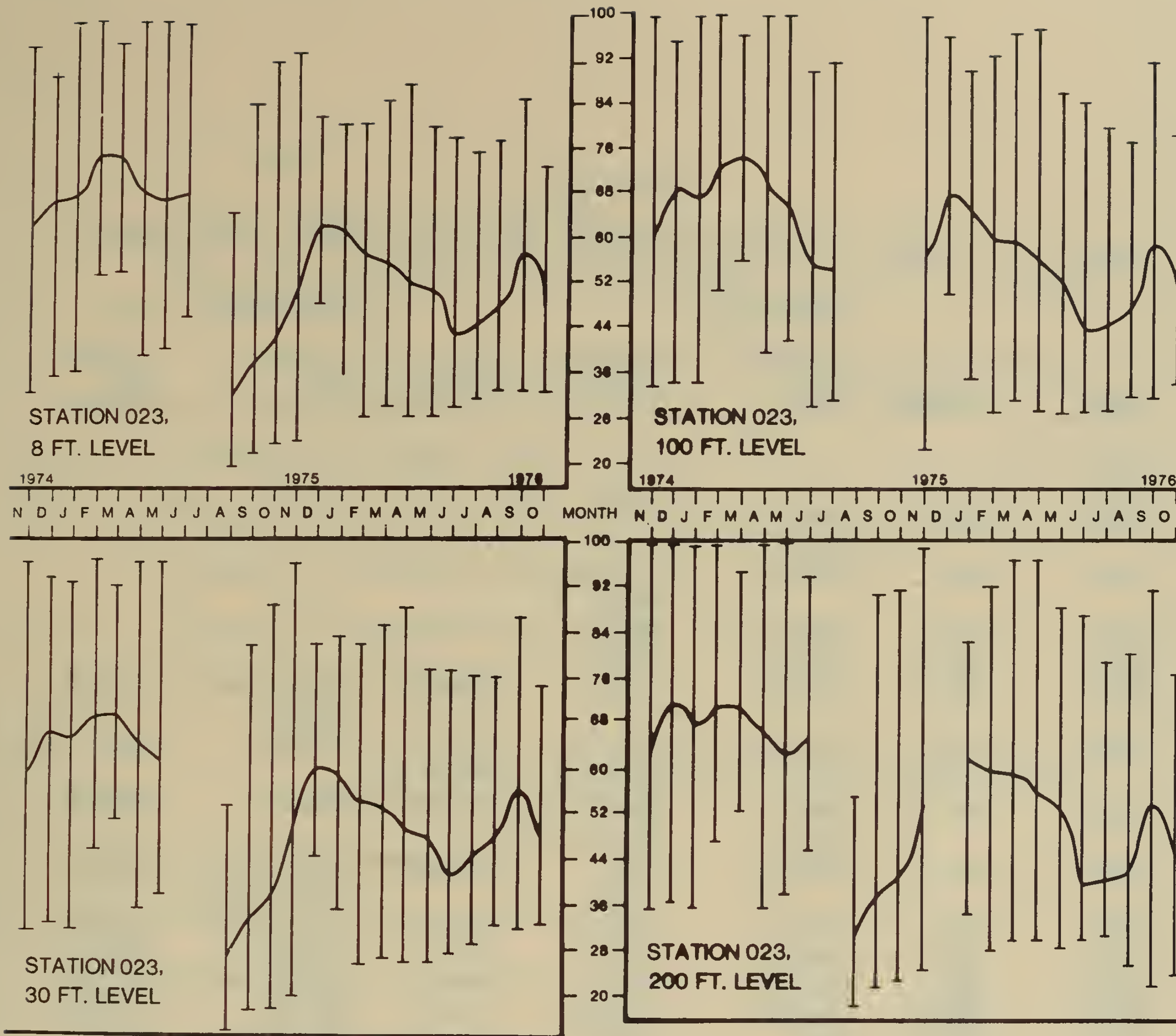
*Significant Downtime to Possibly Affect Totals.



RELATIVE HUMIDITY (%)

FIGURE B-16a MONTHLY AVERAGE AND DAILY EXTREMA FOR THE MONTH VS. TIME

a. STATIONS 020, 021, 022, 024



RELATIVE HUMIDITY (%)

FIGURE B-16b MONTHLY AVERAGE AND DAILY EXTREMA FOR THE MONTH VS. TIME

b. STATION 023

Table B-17

Table B-17 MONTHLY BAROMETRIC PRESSURE AND DAILY EXTREMA (IN MILLIBARS)

	TRAILER 023			TRAILER 024		
MONTH	AVERAGE	HIGHEST/ DATE	LOWEST/ DATE	AVERAGE	HIGHEST/ DATE	LOWEST/ DATE
11/74	--	--	--	--	--	--
12/74	--	--	--	--	--	--
1/75	785.7	795/ 12,13,19	770/9	--	--	--
2/75	785.1	*794/23	777/10, 16,20	-- --	-- --	-- --
3/75	*782.2	790/1,3,7	769/26	--	--	--
4/75	782.4	790/20	771/7	--	--	--
5/75	785.8	792/10	773/20	*789.6	795/9,10, 13,26	776/20
6/75	*778.2	793/30	778/17, 18	*791.3	796/30	781/17,18
7/75	791.3	794/ 3,4,10	788/ 15,17,29	795.3	799/4	792/29
8/75	791.5	794/1,2	789/ 18,24	796.0	798/ 1,2,9,15,16	792/24
9/75	793.5	799/22	789/18	797.2	803/22	792/18
10/75	790.7	798/29	782/7	793.7	802/29	782/22
11/75	789.1	800/12	770/28	*792.7	803/12	772/28
12/75	791/2	798/20	780/12	794.0	802/20	776/31
1/76	791.3	799/ 16,20,21	781/24	794.9	802/20,21	785/24
2/76	787.9	799/22	775/4	791.4	804/22	778/4
3/76	785.2	793/6,16	775/1	788.4	796/ 6,16,22	778/1
4/76	*785.9	790/19	781/17	789.0	799/30	776/16
5/76	*789.6	795/12	784/5*	*792.9	798/12	787/5,29
6/76	789.8	795/ 27*,28	784/11	793.2	799/28	787/11
7/76	*792.4	796/23	789/12	*795.9	799/24	791/2
8/76	793.1	797/28,29	787/15	797.0	801/28	792/12
9/76	792.9	799/9	787/26	796.1	803/9	790/26
10/76	791.6	797/7,8	786/22	794.6	800/7,8	789/22
AVERAGE	788.9	--	--	793.5	--	--

*Incomplete

B.2 Air Quality

B.2.1 Gaseous Concentrations

The following figures and tables support Section 3.2.1, Gaseous Concentrations:

Two Annual Time Series of 24-Hour Concentrations of Sulfur Dioxide

Figure B-17a Station 020

Figure B-17b Station 021

Figure B-17c Station 022

Figure B-17d Station 023

Figure B-17e Station 024

Two Annual Time Series of 24-Hour Concentrations of Hydrogen Sulfide

Figure B-18a Station 020

Figure B-18b Station 021

Figure B-18c Station 022

Figure B-18d Station 023

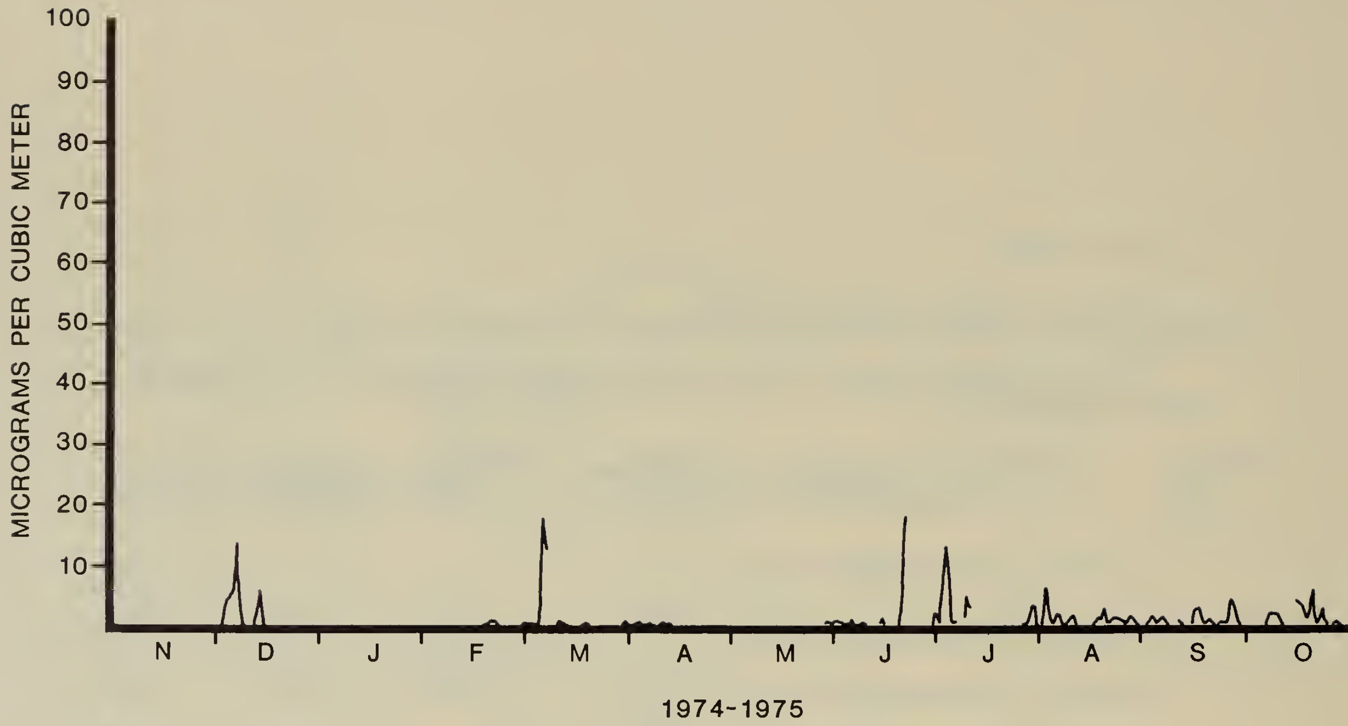
Figure B-18e Station 024

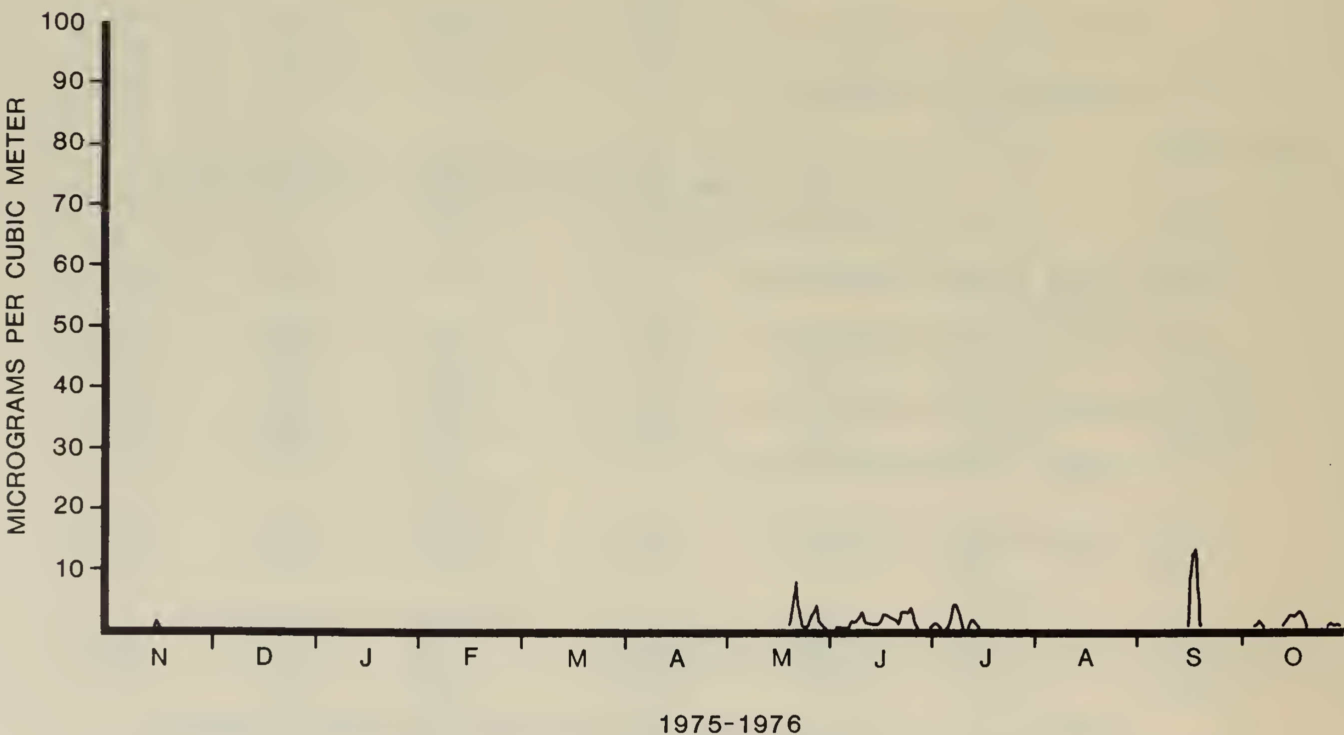
Figure B-19 Two Annual Time Series of 24-Hour Concentrations of Nitrogen Dioxide

Figure B-20 Two Annual Time Series of 24-Hour Concentrations of Nitrogen Oxides

Figure B-21 Two Annual Time Series of 24-Hour Concentrations of Nitric Oxide

Figure B-22 Two Annual Time Series of 24-Hour Concentrations of Ozone



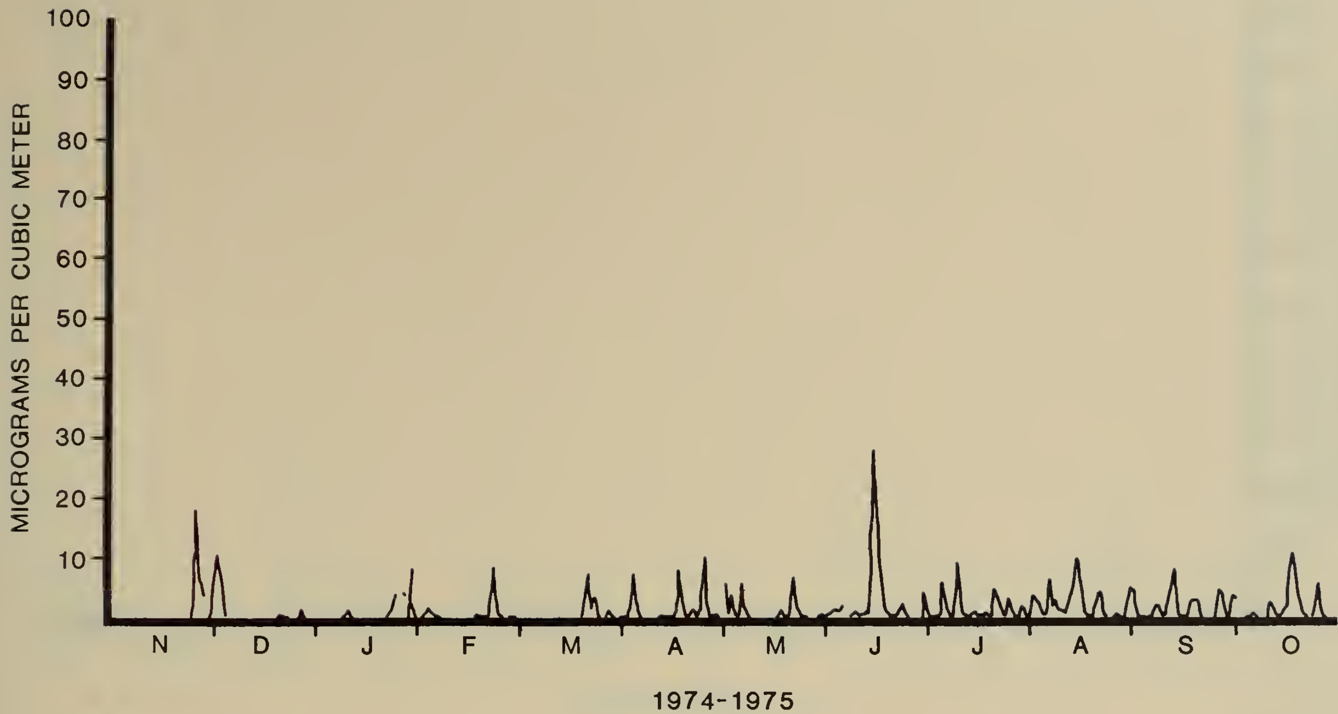


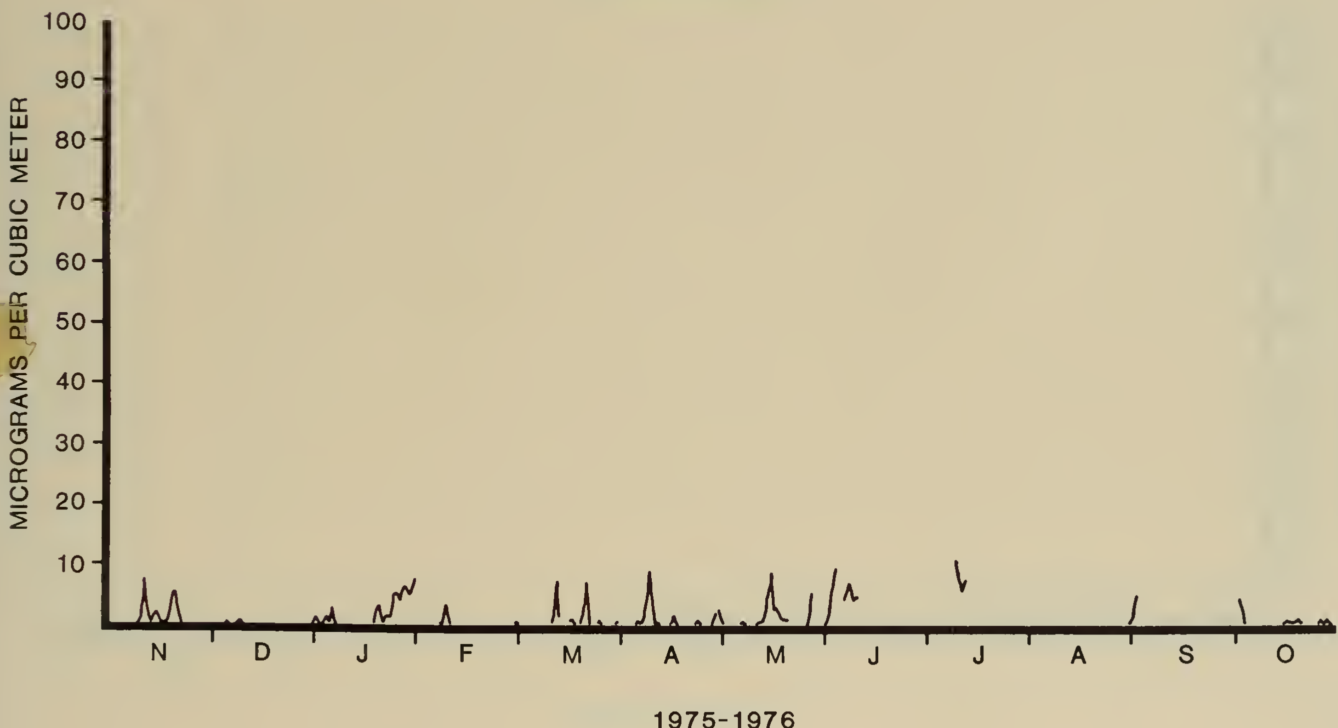
STATION 020

TWO ANNUAL TIME SERIES

OF 24 HOUR CONCENTRATIONS OF SULFUR DIOXIDE

FIGURE B-17a



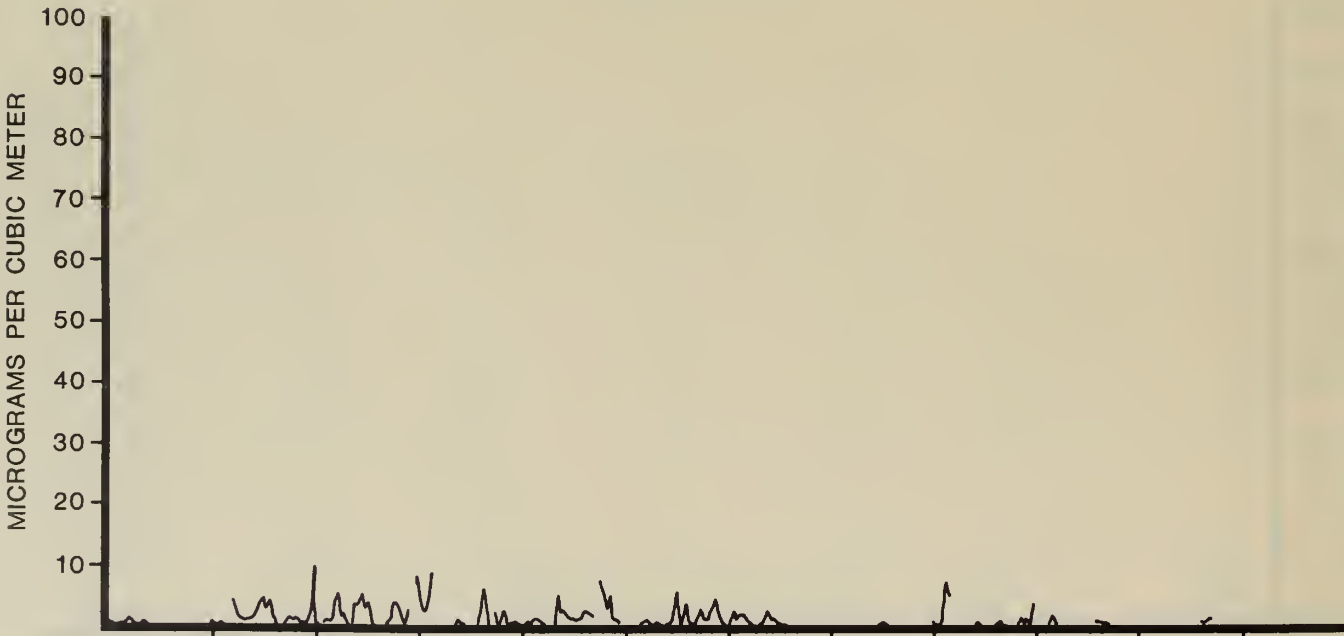


STATION 021

TWO ANNUAL TIME SERIES

OF 24 HOUR CONCENTRATIONS OF SULFUR DIOXIDE

FIGURE B-17 b

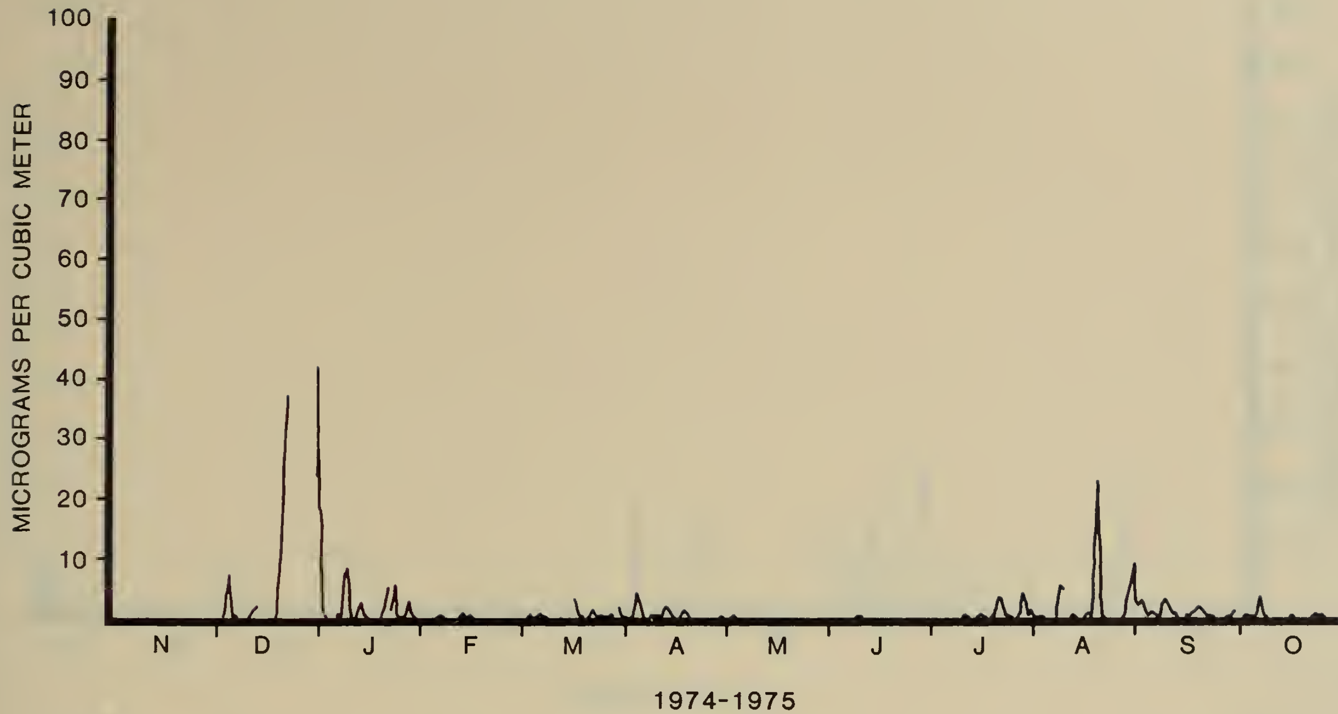


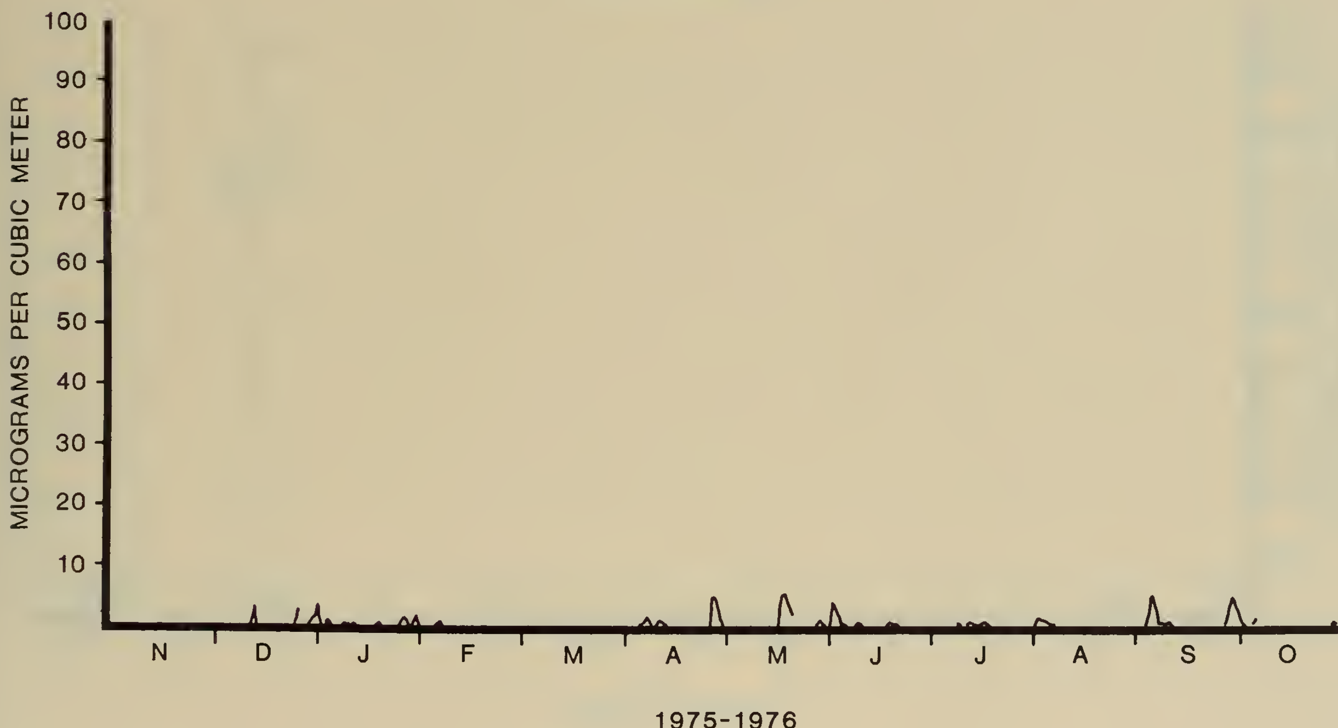
STATION 022

TWO ANNUAL TIME SERIES

OF 24 HOUR CONCENTRATIONS OF SULFUR DIOXIDE

FIGURE B-17c



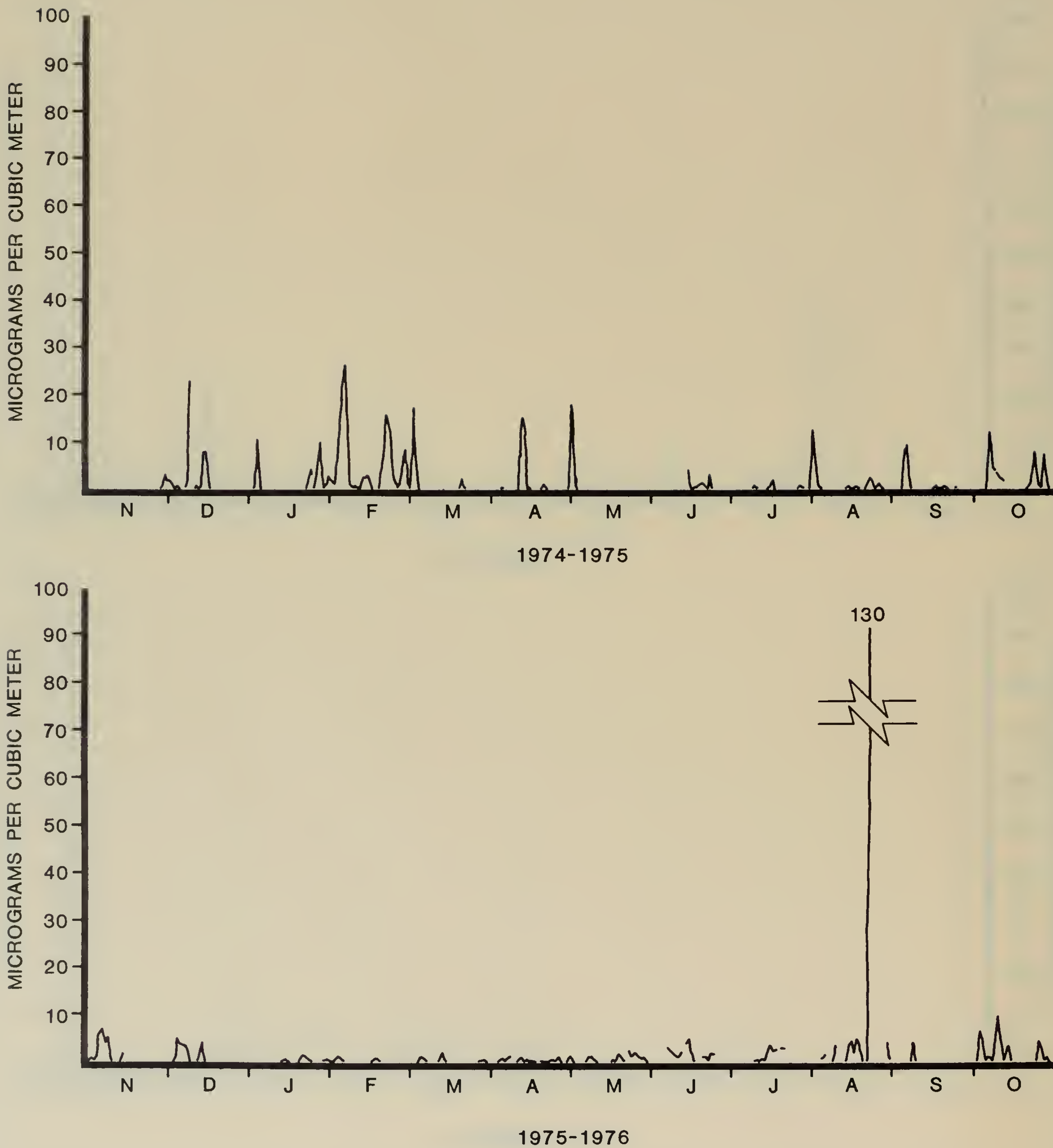


STATION 023

TWO ANNUAL TIME SERIES

OF 24 HOUR CONCENTRATIONS OF SULFUR DIOXIDE

FIGURE B-17d

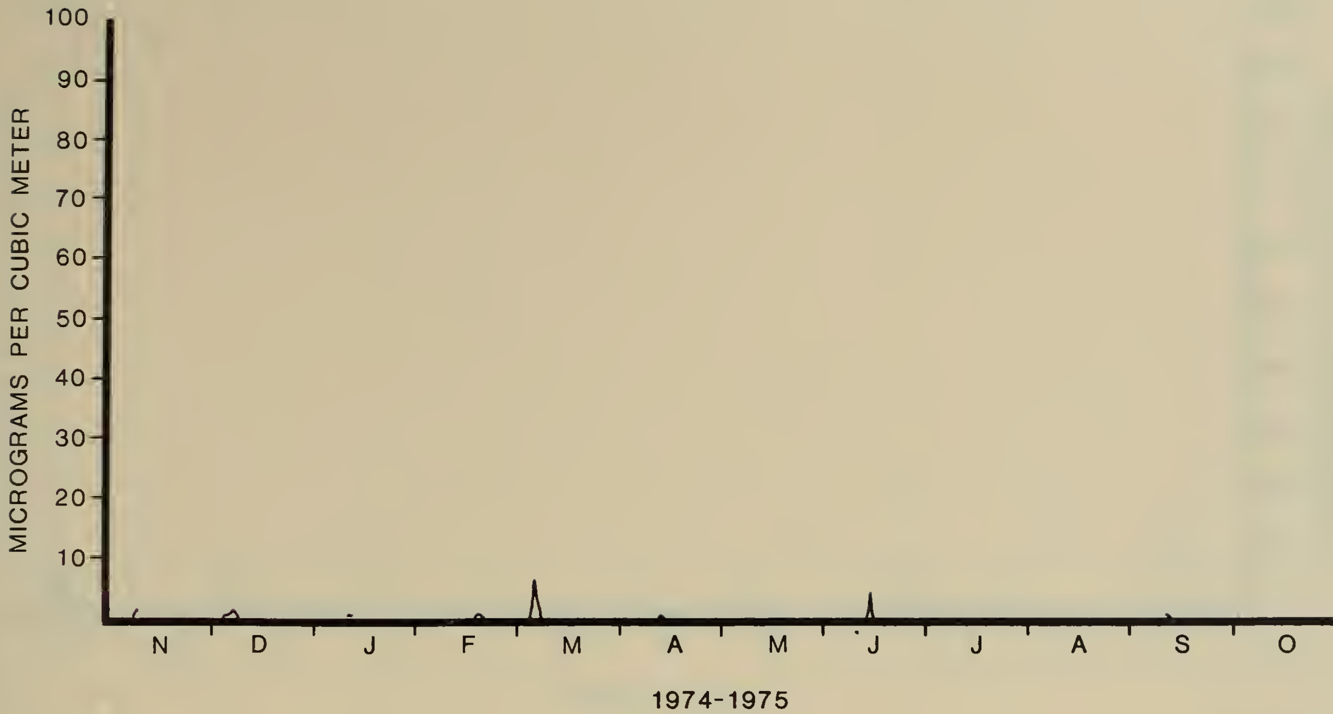


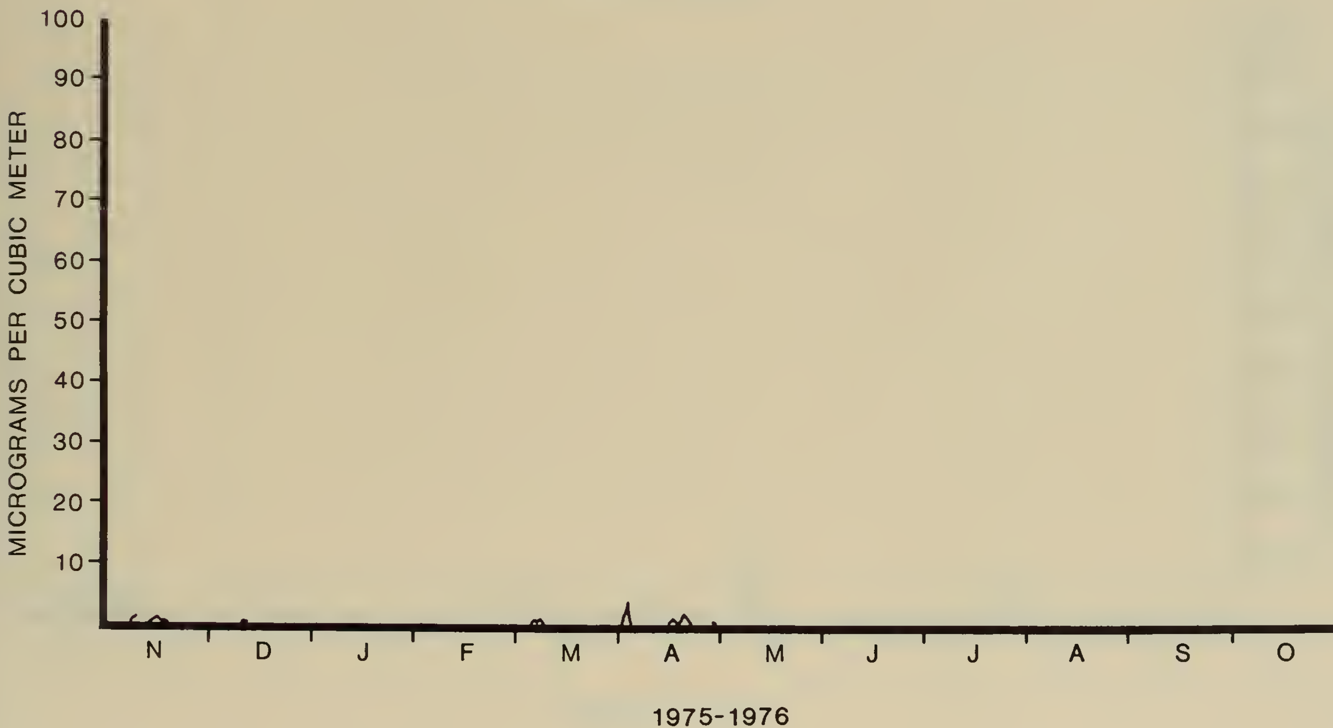
STATION 024

TWO ANNUAL TIME SERIES

OF 24 HOUR CONCENTRATIONS OF SULFUR DIOXIDE

FIGURE B-17e

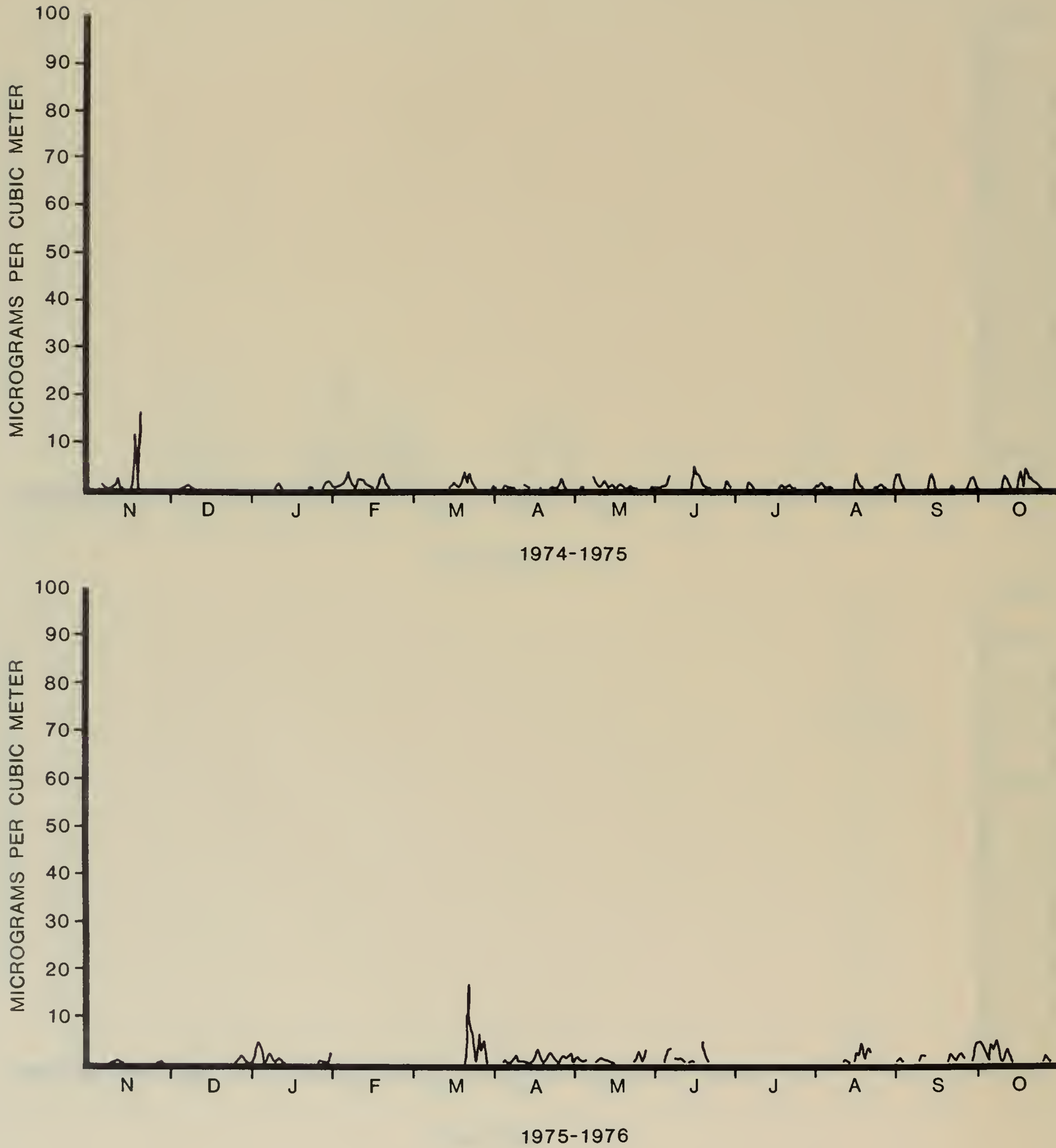




STATION 020

TWO ANNUAL TIME SERIES OF 24 HOUR CONCENTRATIONS OF HYDROGEN SULFIDE

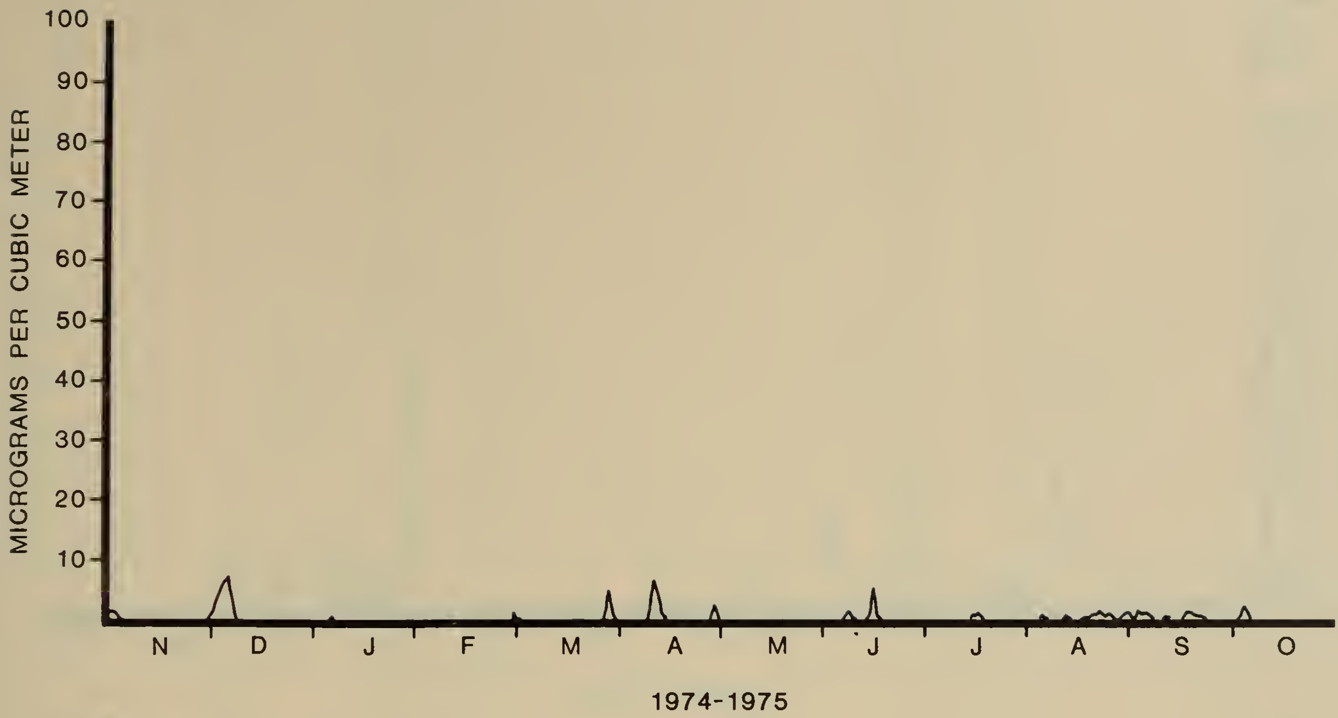
FIGURE B-18 a

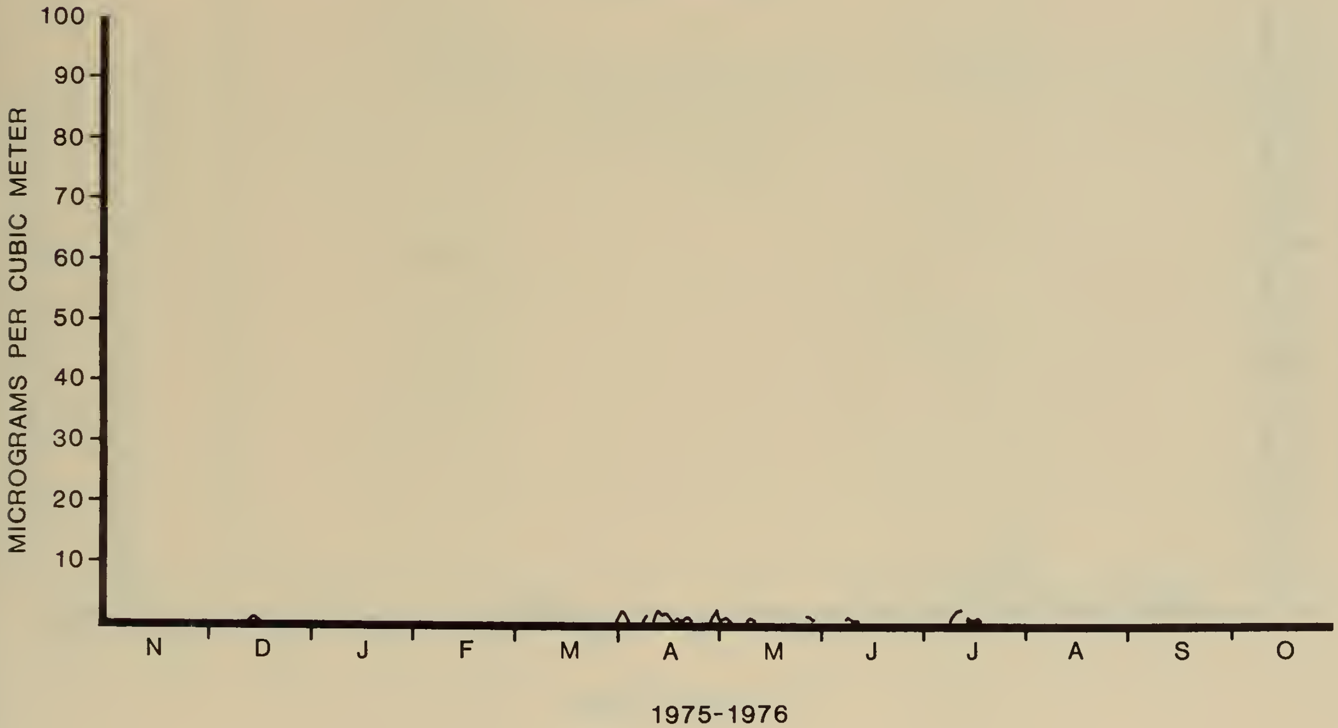


STATION 021

TWO ANNUAL TIME SERIES OF 24 HOUR CONCENTRATIONS OF HYDROGEN SULFIDE

FIGURE B-18 b

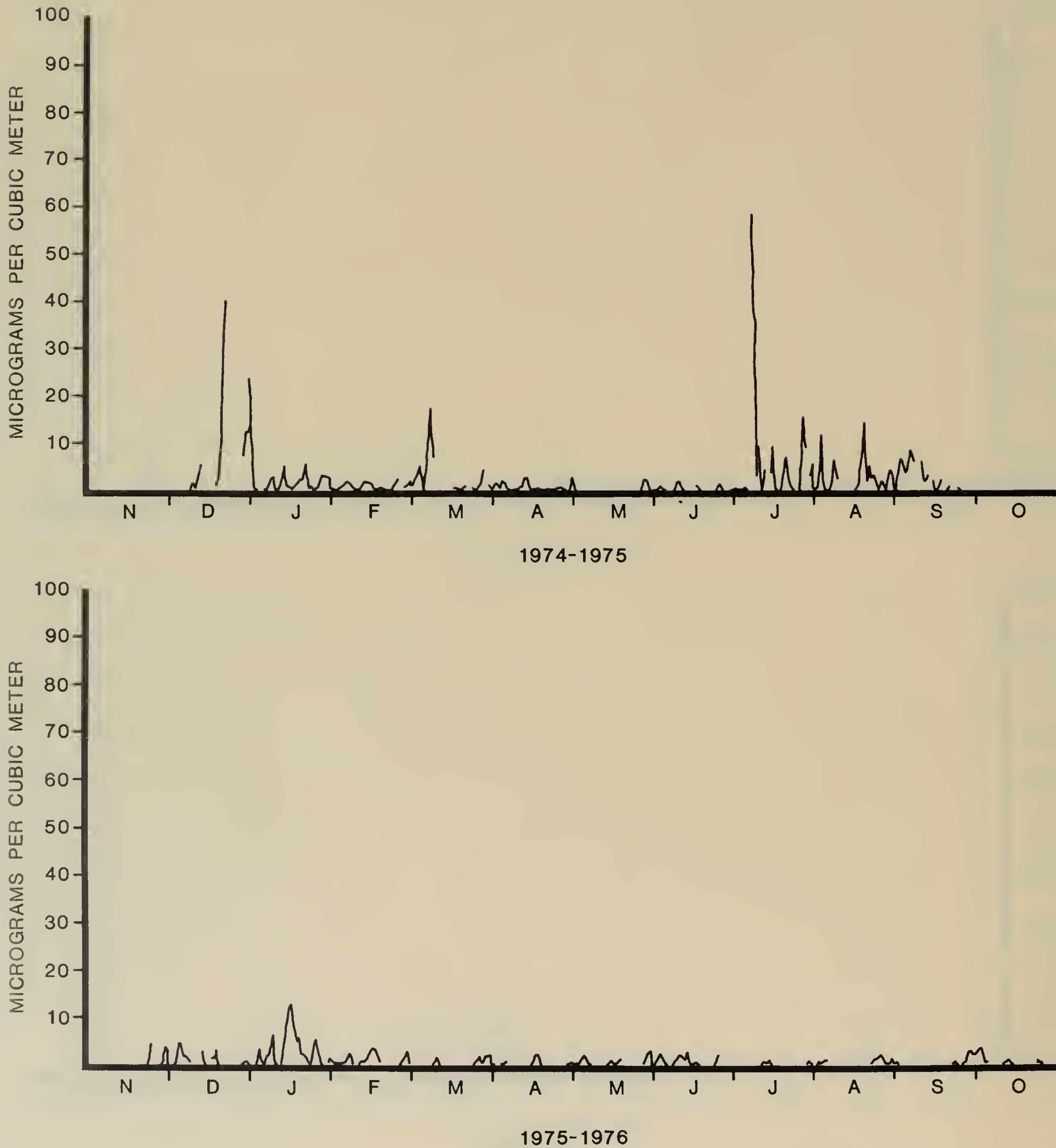




STATION 022

TWO ANNUAL TIME SERIES OF 24 HOUR CONCENTRATIONS OF HYDROGEN SULFIDE

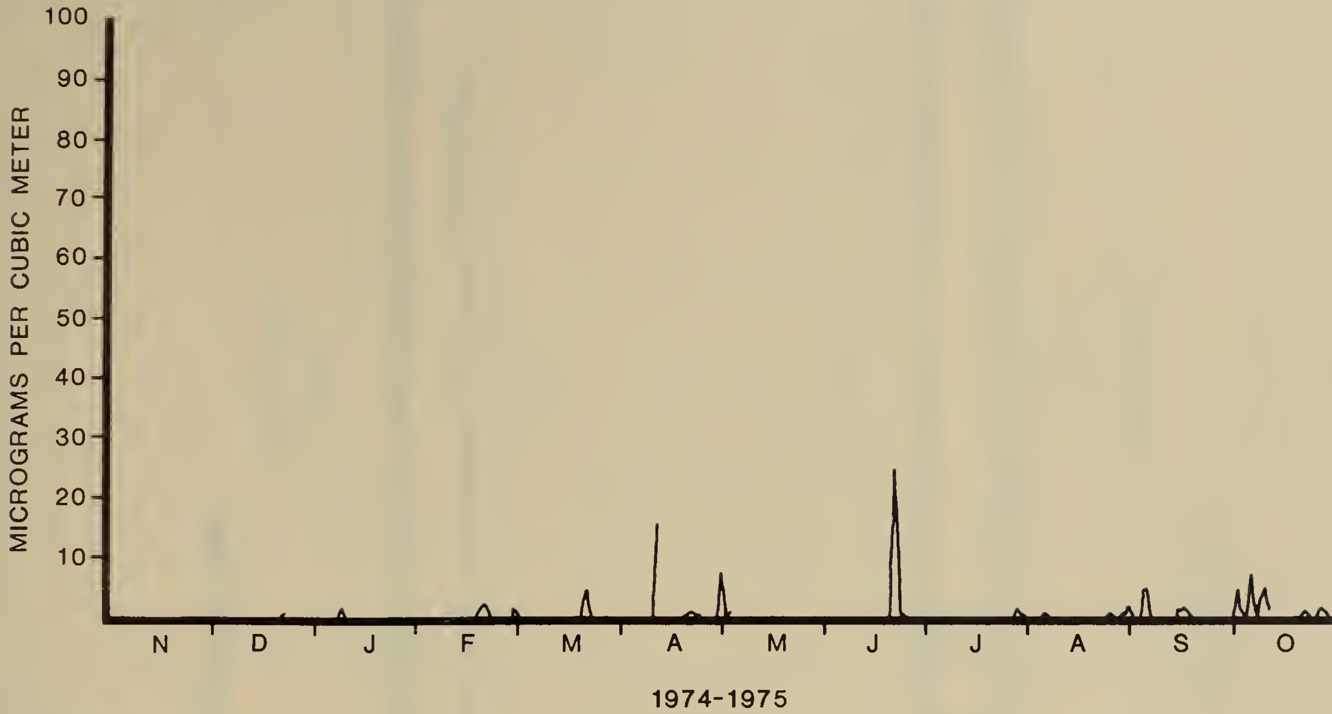
FIGURE B-18c

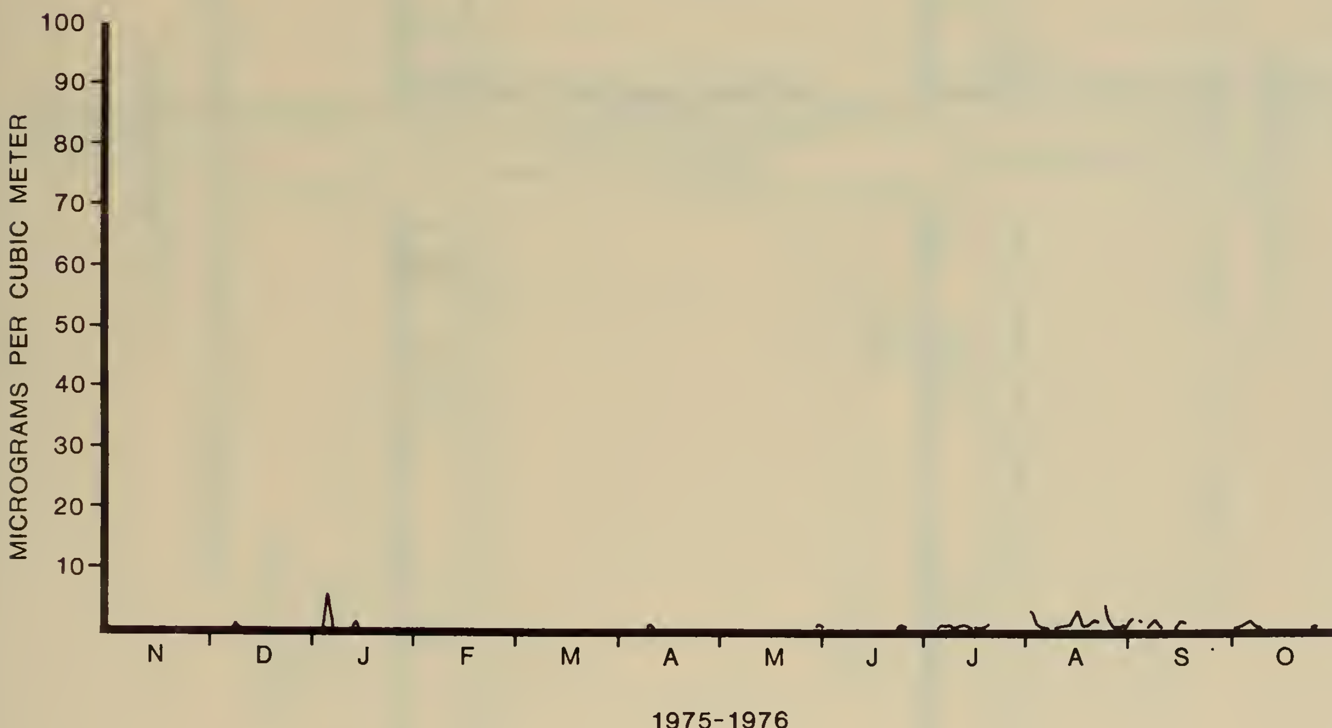


STATION 023

TWO ANNUAL TIME SERIES OF 24 HOUR CONCENTRATIONS OF HYDROGEN SULFIDE

FIGURE B-18d

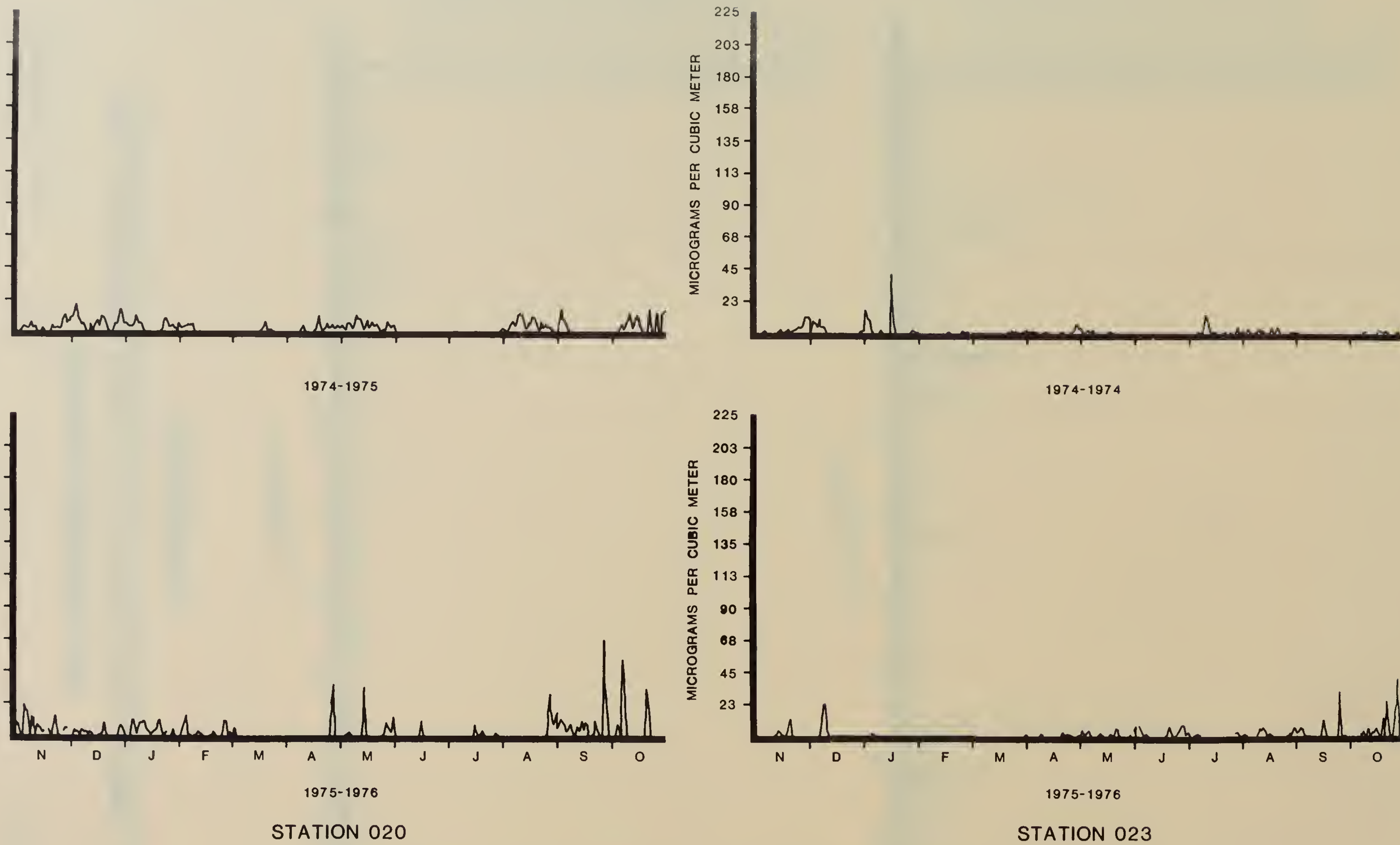




STATION 024

TWO ANNUAL TIME SERIES OF 24 HOUR CONCENTRATIONS OF HYDROGEN SULFIDE

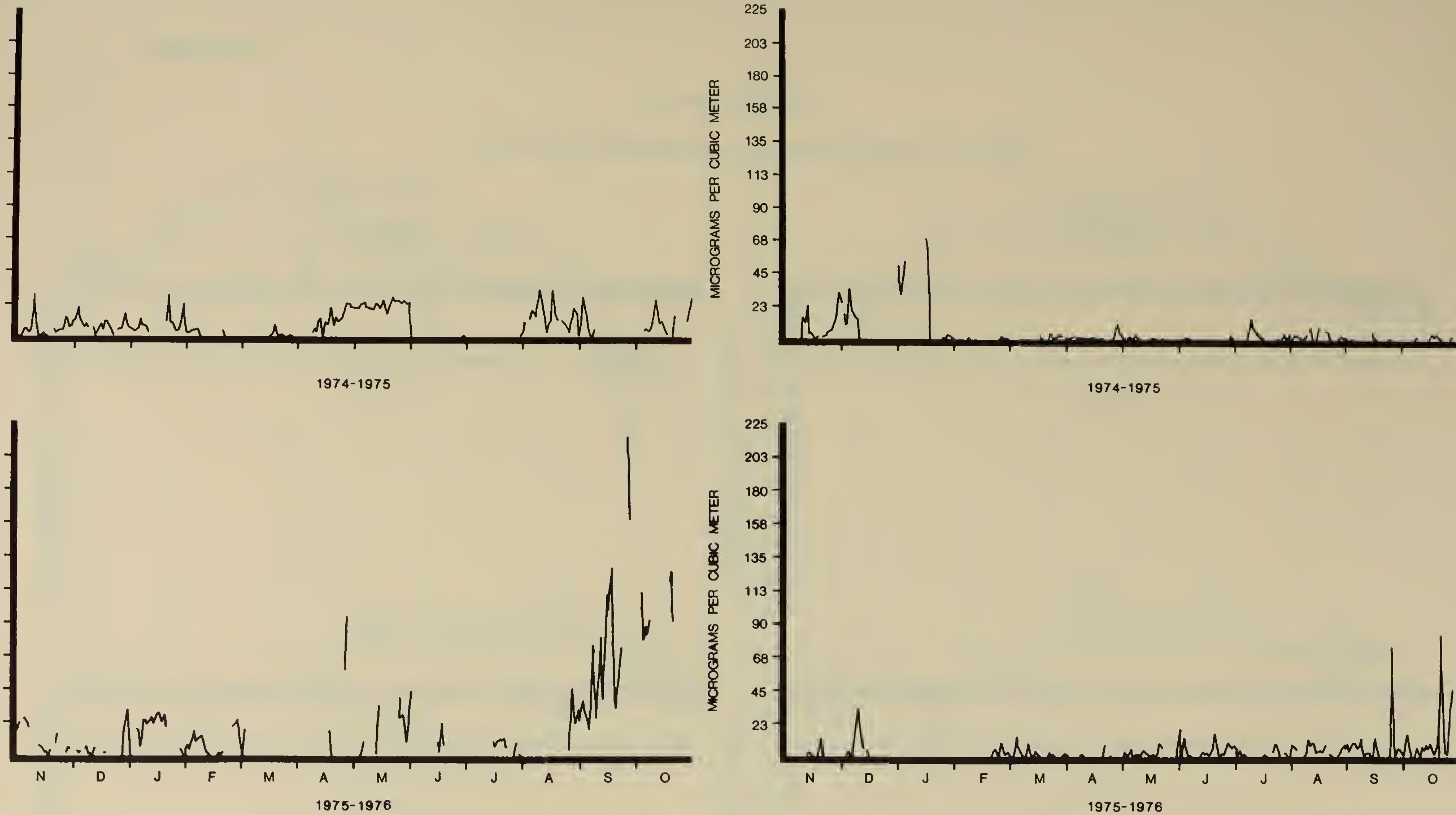
FIGURE B-18 e



TWO ANNUAL TIME SERIES OF 24 HOUR CONCENTRATIONS

OF NITROGEN DIOXIDE

FIGURE B-19



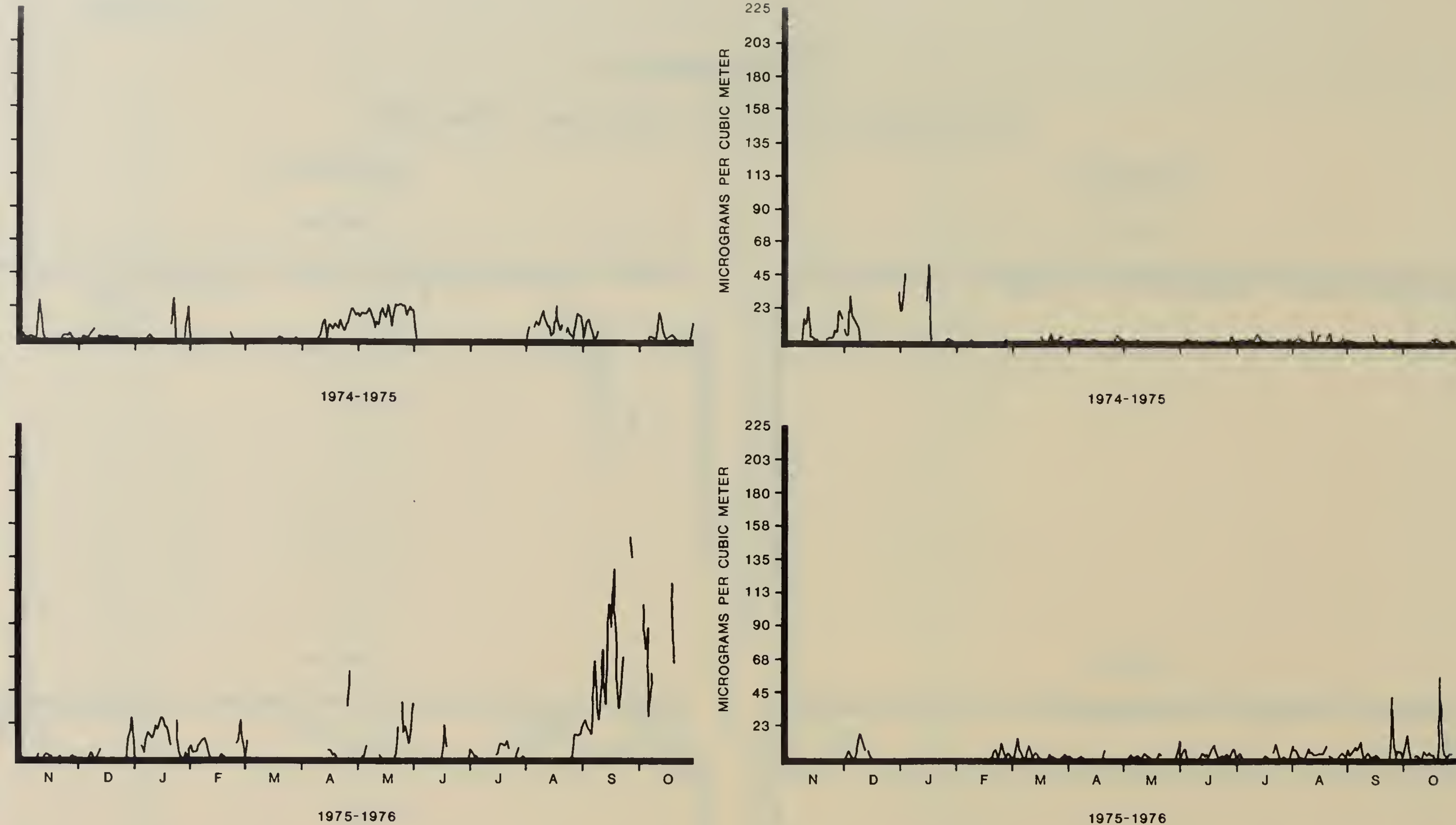
STATION 020

STATION 023

TWO ANNUAL TIME SERIES OF 24-HOUR CONCENTRATIONS

OF NITROGEN OXIDES

FIGURE B-20



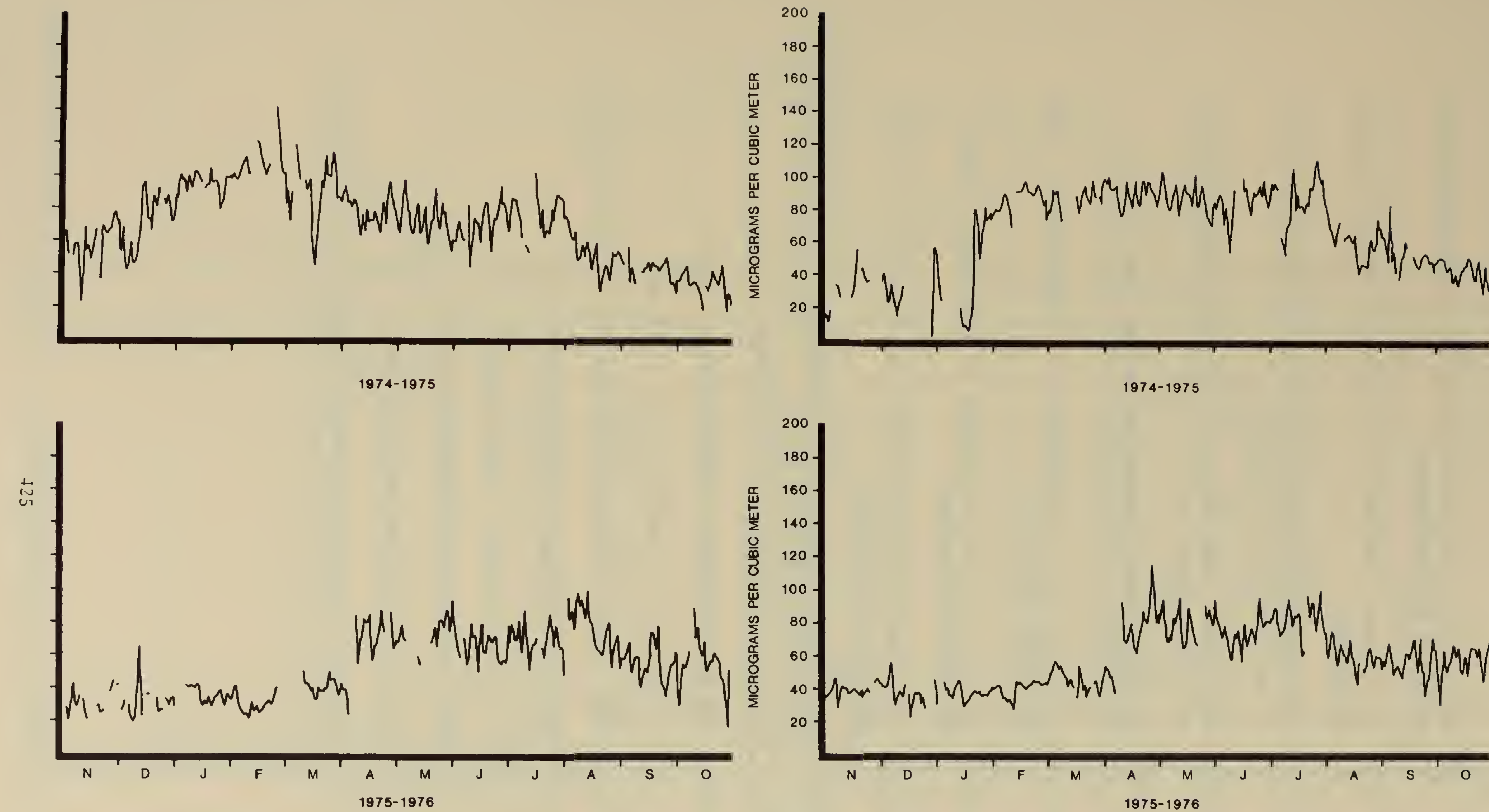
STATION 020

STATION 023

TWO ANNUAL TIME SERIES OF 24 HOUR CONCENTRATIONS

OF NITRIC OXIDE

FIGURE B-21



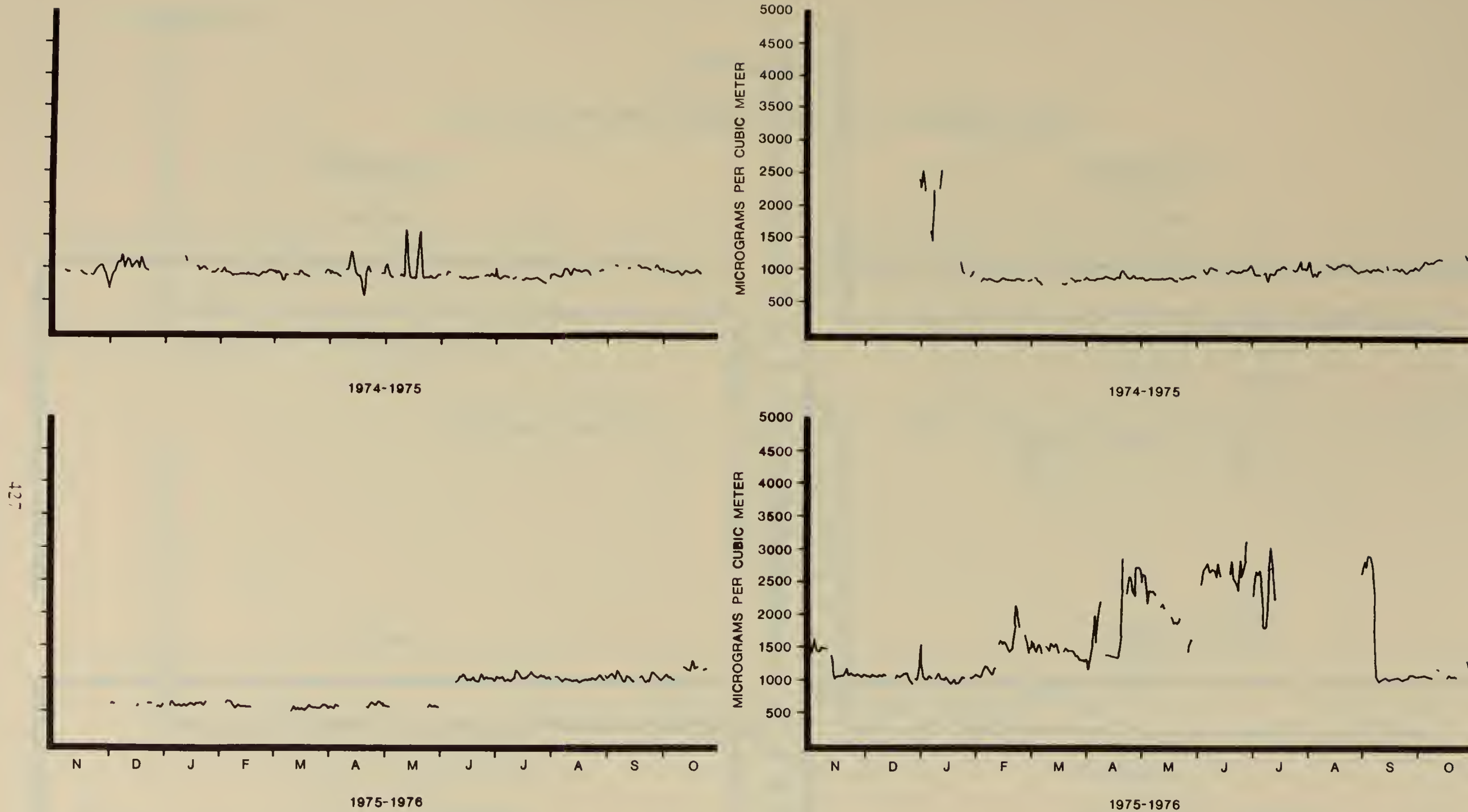
STATION 020

STATION 023

TWO ANNUAL TIME SERIES OF 24-HOUR CONCENTRATIONS

OF OZONE

FIGURE B-22



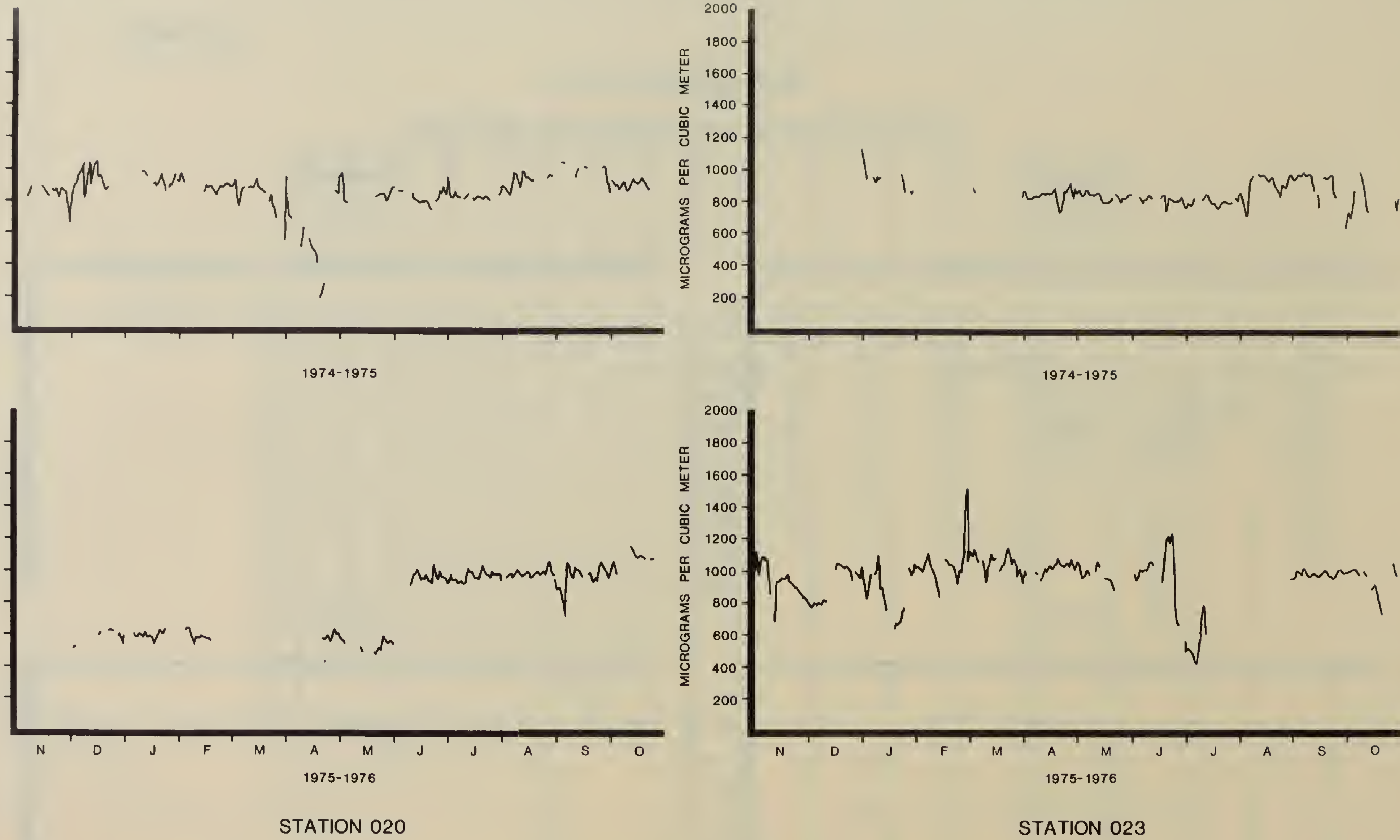
STATION 020

STATION 023

TWO ANNUAL TIME SERIES OF 24 HOUR CONCENTRATIONS

OF TOTAL HYDROCARBONS

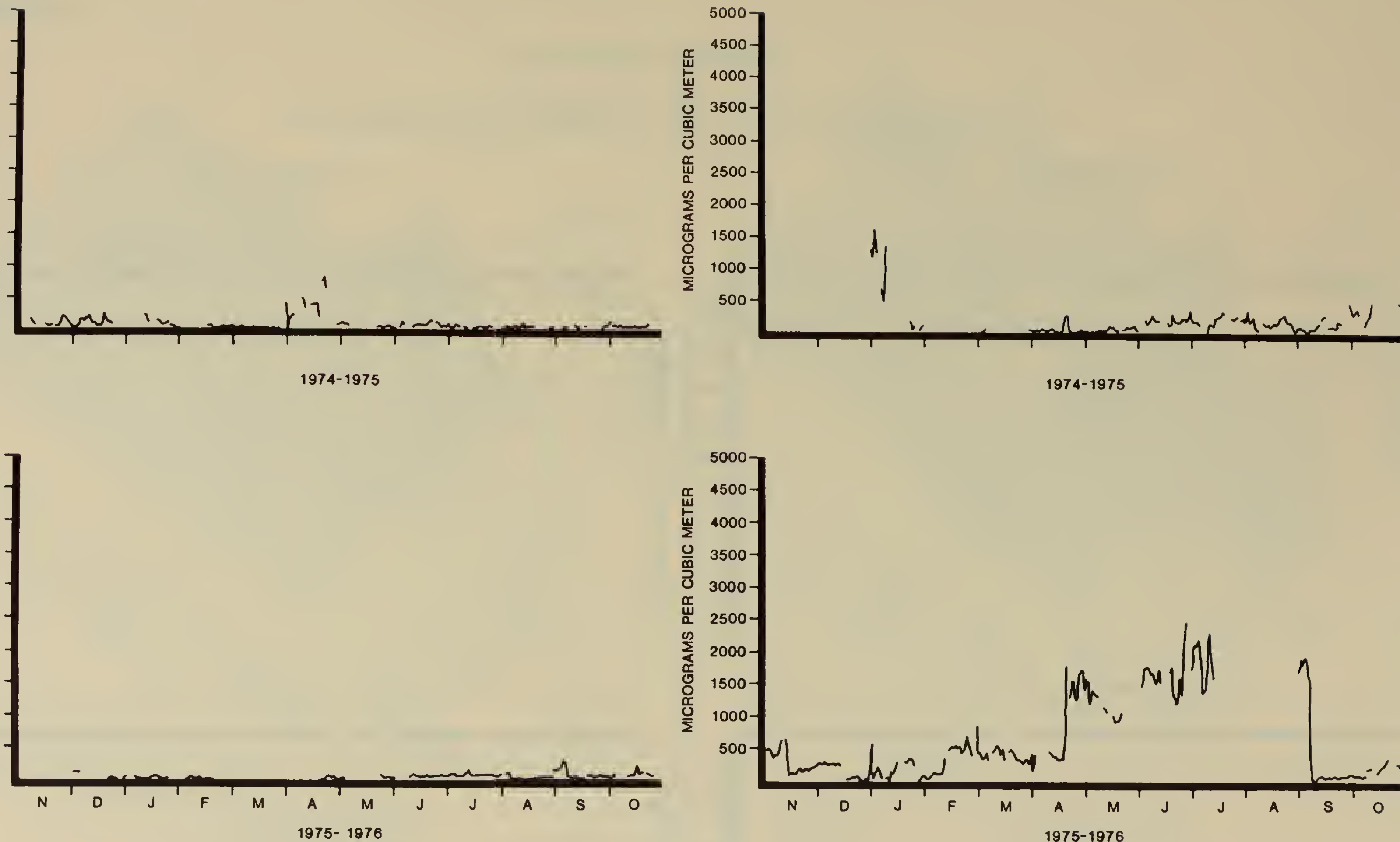
FIGURE B-23



TWO ANNUAL TIME SERIES OF 24-HOUR CONCENTRATIONS

OF METHANE

FIGURE B-24



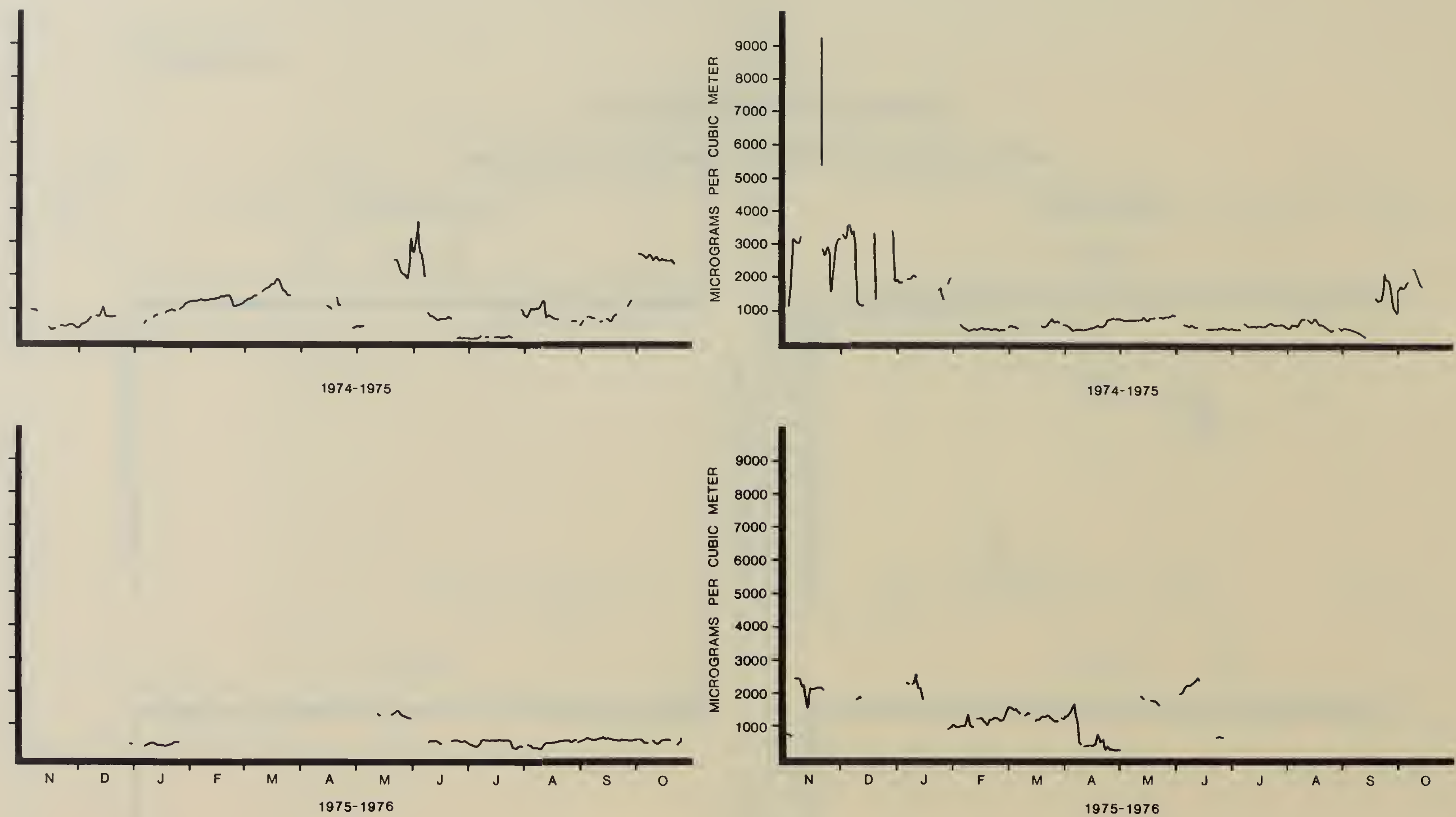
STATION 020

STATION 023

TWO ANNUAL TIME SERIES OF 24-HOUR CONCENTRATIONS

OF NON-METHANE HYDROCARBONS

FIGURE B-25



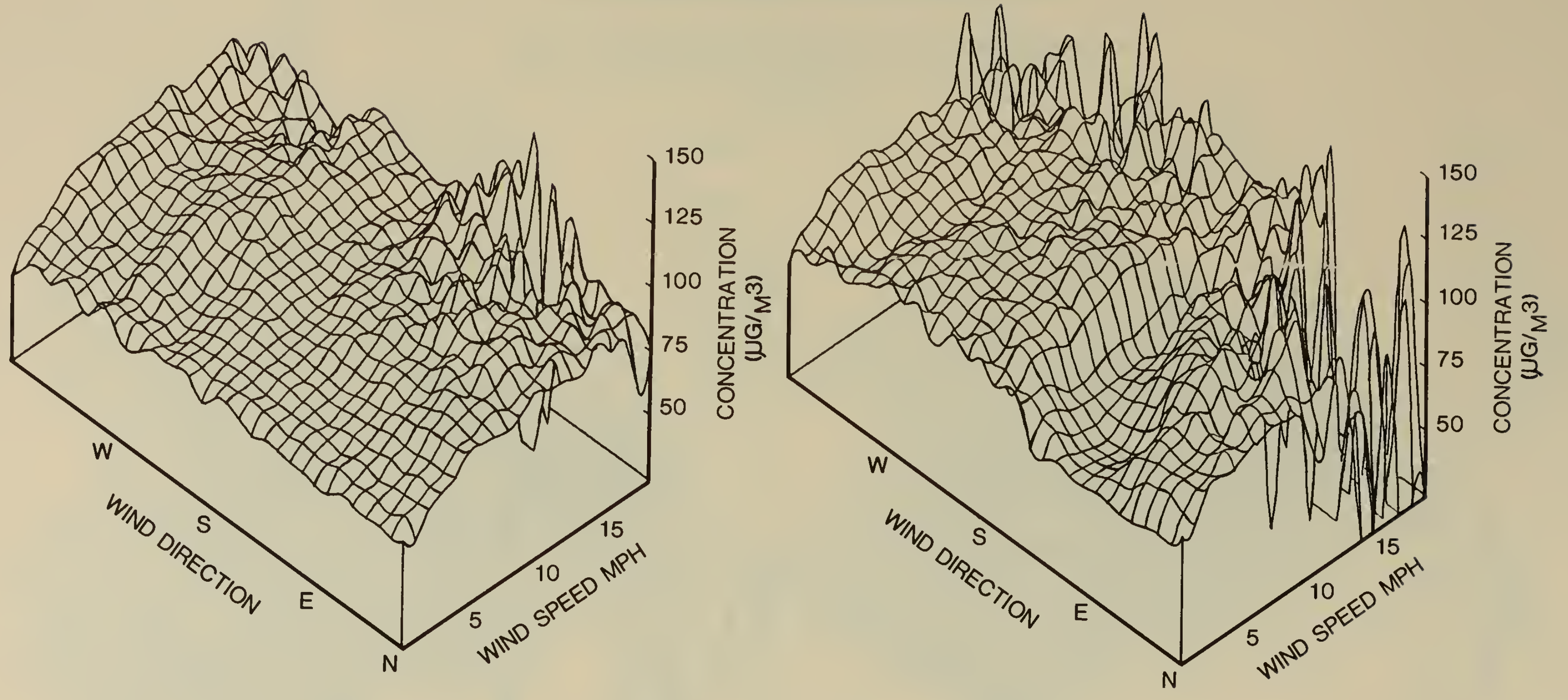
STATION 020

STATION 023

TWO ANNUAL TIME SERIES OF 24-HOUR CONCENTRATIONS

OF CARBON MONOXIDE

FIGURE B-26

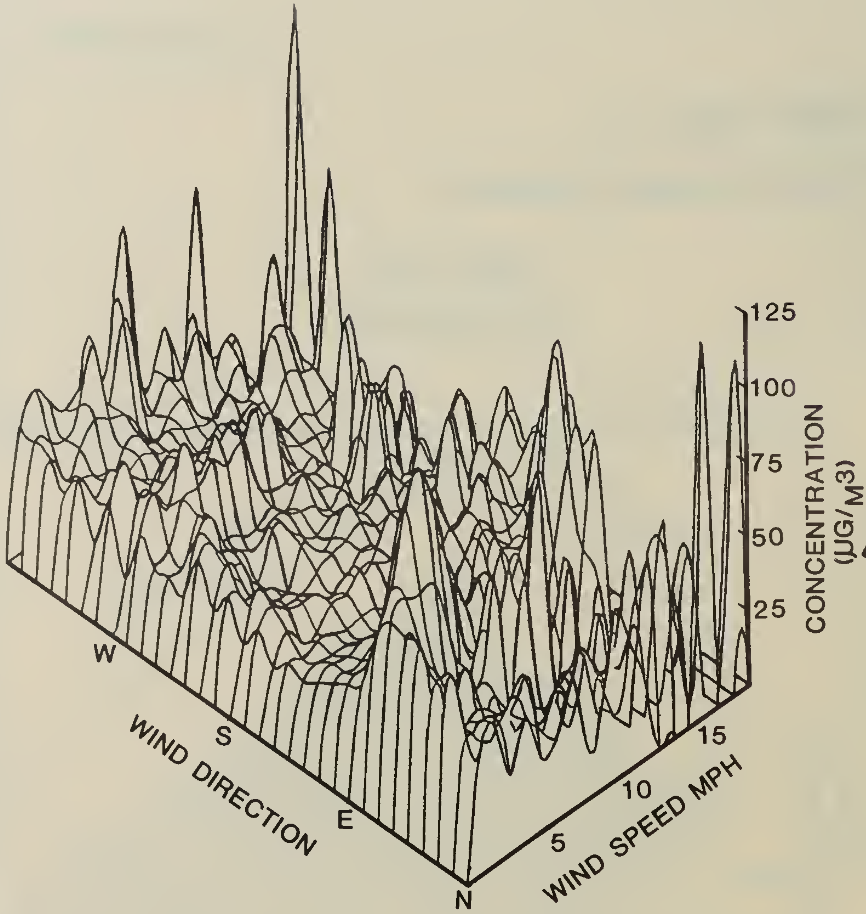


STATION 020
1974-1976

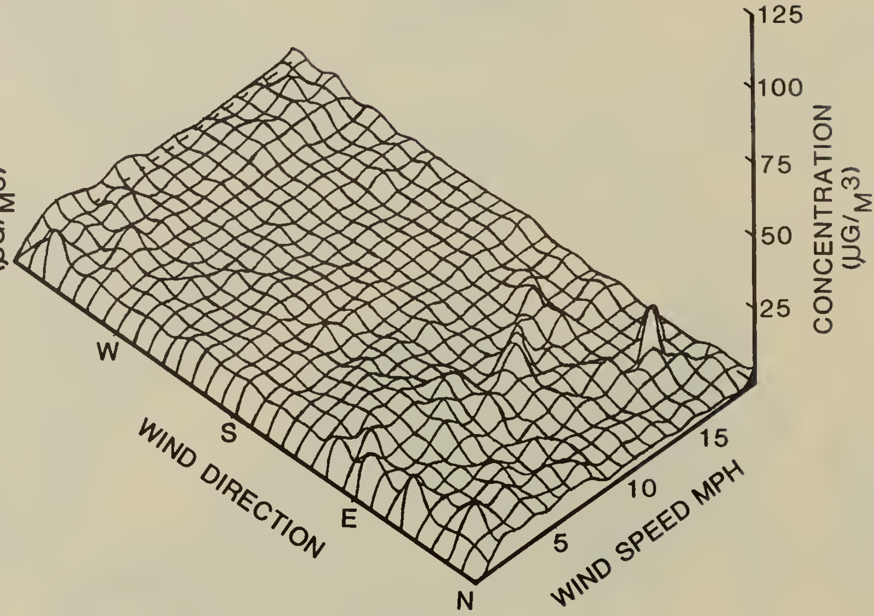
STATION 023
1974-1976

5-MINUTE OZONE CONCENTRATIONS AS FUNCTIONS
OF WIND SPEED AND DIRECTION

FIGURE B-27



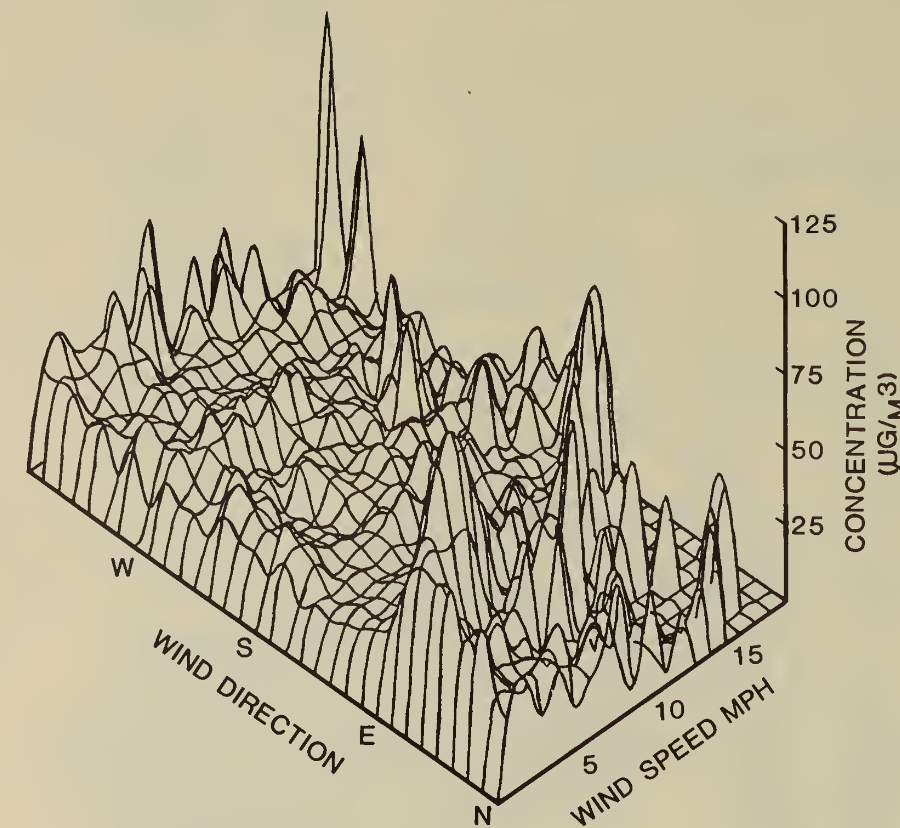
STATION 020
1974-1976



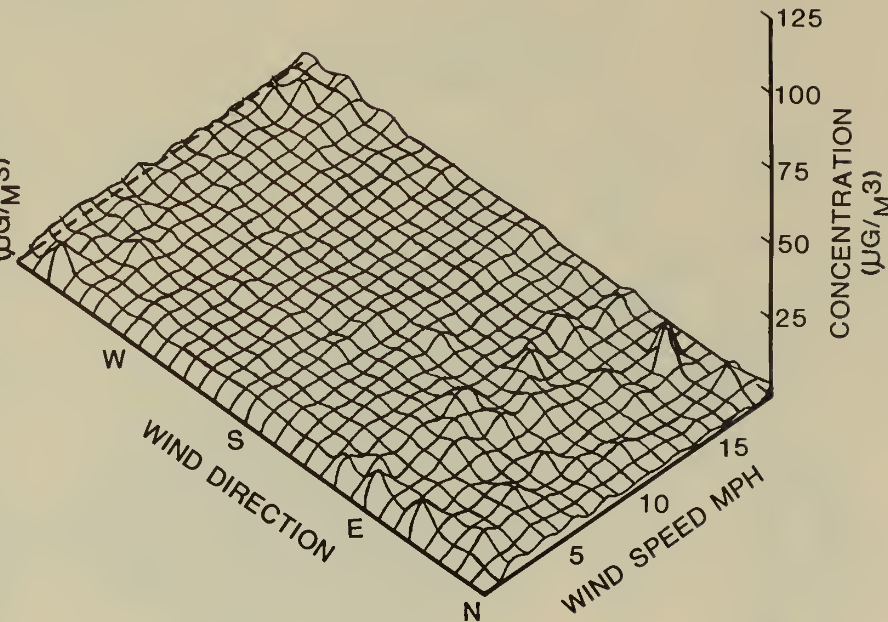
STATION 023
1974-1976

5-MINUTE
NOX CONCENTRATIONS AS FUNCTIONS
OF WIND SPEED AND DIRECTION

FIGURE B-28



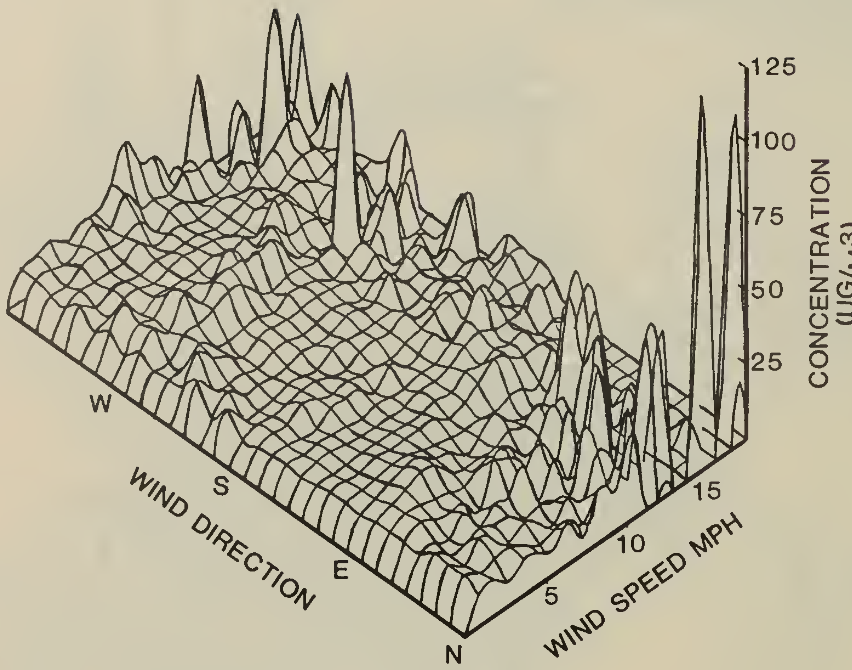
STATION 020
1974-1976



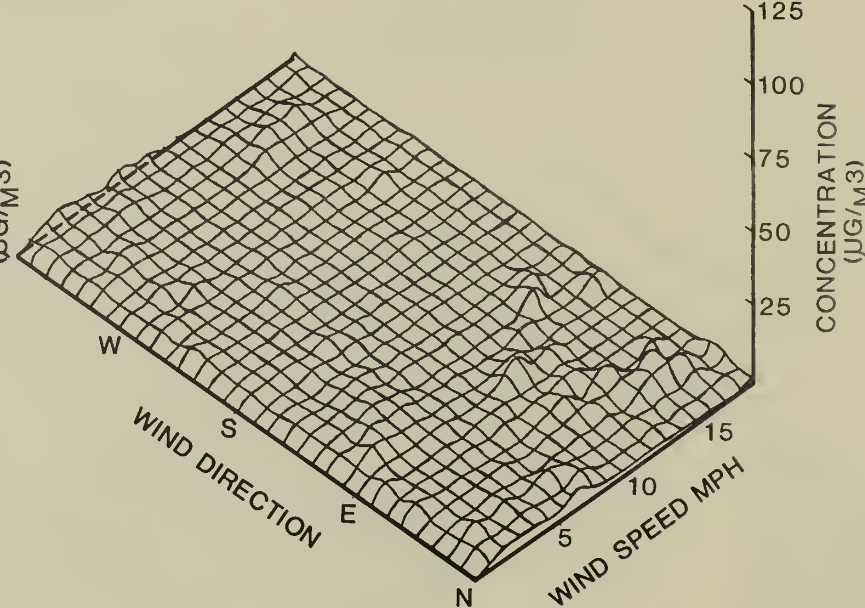
STATION 023
1974-1976

5-MINUTE
NO CONCENTRATIONS AS FUNCTIONS
OF WIND SPEED AND DIRECTION

FIGURE B-29



STATION 020
1974-1976



STATION 023
1974-1976

5-MINUTE
NO_2 CONCENTRATIONS AS FUNCTIONS
OF WIND SPEED AND DIRECTION

FIGURE B-30

Table B-18
TEN HIGHEST ONE HOUR SO_2 AVERAGES DURING BASELINE

Site		1	2	3	4	5	6	7	8	9	10
020	Concentration (μg/m^3)	189.1	111.6	109.8	82.3	33.9	32.8	31.3	31.0	31.0	31.0
	Date/Time	9/18/76	9/18/76	9/17/76	9/17/76	7/14/75	3/7/75	3/8/75	3/7/75	3/7/75	3/8/75
		3:00	5:55	21:40	22:50	13:10	10:05	3:05	11:10	23:25	00:45
	Wind Speed (mph)	3	6	7	7	1	10	5	10	5	1
	Wind Direction	96	119	111	115	157	186	113	189	111	107
021	Concentration (μg/m^3)	67.9	65.8	63.2	60.3	56.0	53.4	34.3	32.8	32.8	31.7
	Date/Time	6/16/75	6/16/75	6/16/75	6/16/75	6/16/75	1/26/75	5/5/75	11/1/74	3/7/75	5/5/75
		13:45	15:15	16:20	17:25	18:30	14:05	10:50	1:35	10:05	11:55
	Wind Speed (mph)	15	19	16	7	1	10	6	5	9	7
	Wind Direction	304	309	320	320	339	177	148	133	192	158
022	Concentration (μg/m^3)	27.4	27.1	26.5	26.3	26.0	20.8	18.2	18.0	17.8	17.8
	Date/Time	6/12/75	6/12/75	6/11/75	6/11/75	6/11/75	12/20/74	5/23/75	5/24/75	5/24/75	2/1/76
		0:00	1:15	21:05	19:30	16:45	1:15	20:55	2:25	3:40	7:35
	Wind Speed (mph)	7	9	0	3	6	6	3	2	1	10
	Wind Direction	123	117	71	41	282	116	80	61	97	115
023	Concentration (μg/m^3)	97.9	59.9	59.3	58.0	54.9	54.6	52.6	50.7	50.6	49.9
	Date/Time	12/21/74	8/20/75	8/20/75	8/20/75	8/20/75	3/22/76	3/22/76	3/22/76	1/1/75	1/1/75
		1:55	4:15	5:20	6:25	7:30	14:20	15:25	16:30	14:30	11:35
	Wind Speed (mph)	6	2	1	2	2	9	8	7	5	6
	Wind Direction	158	171	186	178	94	144	146	141	17	340
024	Concentration (μg/m^3)	128.5	113.1	76.8	56.4	54.3	54.1	51.7	50.8	50.8	49.5
	Date/Time	12/10/74	8/23/76	8/23/76	5/2/75	1/5/75	5/2/75	12/10/74	3/3/75	3/4/75	5/2/75
		6:20	10:30	15:25	3:20	11:50	4:25	7:25	22:50	00:05	5:30
	Wind Speed (mph)	0	12	12	1	11	2	0	4	4	2
	Wind Direction	4	206	250	97	173	91	54	62	55	111

SO_2
Constituent

Table B-19
1- HOUR MAXIMUM CONCENTRATIONS
(1974-1975)

By Month

Trailer	Item	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
020	Value (μg/m^3)	4.6	17.4	2.6	7.6	32.8	7.2	7.6	20.8	33.9	12.4	9.1	20.2
	Date	11/1	12/8	1/14	2/20	3/7	4/12	5/30	6/23	7/14	8/4	9/27	10/22
	Time (MST)	13:50	21:48	16:10	10:55	10:05	11:35	14:50	4:45	13:10	13:20	11:30	8:30
	Wind Direction (Deg.)	204	102	134	275	190	266	292	134	157	299	318	182
	Wind Speed (MPH)	5	1	5	12	8	3	7	7	1	5	6	9
023	Value (μg/m^3)	0.2	97.9	50.6	5.0	12.2	8.2	7.2	3.7	13.2	59.9	9.3	7.6
	Date	11/1	12/21	1/1	2/20	3/29	4/5	5/4	6/23	7/28	8/20	9/1	10/7
	Time (MST)	11:15	1:55	14:30	11:30	22:05	10:05	11:00	12:45	19:15	4:15	8:45	23:55
	Wind Direction (Deg.)	191	156	358	236	201	184	186	199	184	171	211	228
	Wind Speed (MPH)	8	7	4	18	3	18	27	11	11	2	12	10
021	Value (μg/m^3)	32.8	25.8	53.4	23.2	21.3	21.7	34.3	67.9	18.2	16.9	11.3	20.8
	Date	11/1	12/19	1/26	2/21	3/25	4/25	5/5	6/16	7/11	8/17	9/2	10/19
	Time (MST)	1:35	15:45	14:05	5:00	9:00	20:25	10:50	13:45	22:55	12:35	19:00	23:50
	Wind Direction (Deg.)	128	324	176	156	154	288	147	304	127	219	116	125
	Wind Speed (MPH)	5	7	10	5	8	11	5	15	5	7	3	2
022	Value (μg/m^3)	13.0	20.8	5.9	11.7	14.1	2.6	18.2	27.4	14.5	16.3	2.4	13.0
	Date	11/6	12/20	1/25	2/22	3/3	4/17	5/23	6/12	7/23	8/17	9/17	10/17
	Time (MST)	17:00	1:15	14:25	8:45	8:30	3:30	20:55	0:00	0:40	14:10	4:55	6:10
	Wind Direction (Deg.)	120	127	275	107	110	291	82	123	114	275	88	121
	Wind Speed (MPH)	1	6	9	2	5	5	1	7	7	5	2	7
024	Value (μg/m^3)	5.2	128.5	54.3	34.3	50.8	49.1	56.4	33.0	10.6	26.5	20.6	41.7
	Date	11/29	12/10	1/5	2/26	3/3	4/13	5/2	6/23	7/17	8/2	9/7	10/8
	Time (MST)	21:10	6:20	11:50	2:25	22:50	17:35	3:20	9:20	19:55	11:05	4:25	4:20
	Wind Direction (Deg.)	80	12	178	63	60	284	103	212	170	317	114	218
	Wind Speed (MPH)	3	0	9	0	3	5	0	5	8	7	7	10

(1975-1976)

Trailer	Item	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
020	Value (μg/m^3)	11.9	.2	0.0*	3.5	1.1	3.5	12.4	11.1	7.6	.9	189.1	10.6
	Date	11/15	12/12		2/17	3/14	4/4	5/22	6/11	7/13	8/24	9/18	10/17
	Time (MST)	18:10	1:35		14:25	9:45	9:45	4:35	4:00	11:35	11:55	3:00	4:35
	Wind Direction (Deg.)	113	99		296	175	173	102	123	279	255	96	86
	Wind Speed (MPH)	4	3		10	8	8	(2)	(2)	(2)	6	3	7
023	Value (μg/m^3)	2.0	19.1	51.4(1)	7.2(1)	54.6	12.8	13.9	6.9	7.2	2.6	9.6	13.5
	Date	11/18	12/13	1/5	2/6	3/22	4/28	5/18	6/3	7/18	8/3	9/7	10/2
	Time (MST)	12:40	7:10	11:10	11:30	14:20	6:40	10:05	13:15	13:00	10:20	8:15	3:35
	Wind Direction (Deg.)	241	139	129	311	144	271	221	194	315	198	72	161
	Wind Speed (MPH)	12	5	14	3	9	1	13	22	14	15	2	3
021	Value (μg/m^3)	11.7	5.2	28.2	10.4	23.4(1)	18.2	18.2	12.8	14.3	4.1	8.5	5.2
	Date	11/12	12/6	1/5	2/1	3/13	4/10	5/16	6/8	7/11	8/12	9/4	10/3
	Time (MST)	11:20	23:40	7:50	0:00	12:10	3:30	3:00	2:20	3:20	15:10	5:50	2:10
	Wind Direction (Deg.)	298	108	132	}CALM	128	104	99	46	89	156	349	107
	Wind Speed (MPH)	4	5	6		7	1	4	1	2	7	0	8
022	Value (μg/m^3)	13.7	13.5	16.9	17.8	17.4	13.0	6.7	1.5	13.7	6.5	6.3	(2)
	Date	11/1	12/7	1/8	2/1	3/14	4/16	5/3	6/17	7/6	8/6	9/23	(2)
	Time (MST)	13:35	14:35	5:10	7:35	0:10	10:25	5:40	2:15	2:55	4:50	7:55	(2)
	Wind Direction (Deg.)	266	125	101	115	CALM	266	117	96	88	118	116	(2)
	Wind Speed (MPH)	6	2	5	10	}	6	8	2	1	7	5	(2)
024	Value (μg/m^3)	22.1	10.0	5.9	3.0	4.6	4.3	4.6	8.7	10.0	113.1	13.7	14.3
	Date	11/7	12/14	1/1	2/4	3/14	4/8	5/20	6/15	7/16	8/23	9/9	10/5
	Time (MST)	3:20	2:30	14:20	12:30	4:30	9:55	5:10	8:10	5:15	10:30	5:35	6:15
	Wind Direction (Deg.)	103	291	286	148	168	342	179	330	119	206	123	106
	Wind Speed (MPH)	4	9	6	19	7	3	4	2	4	12	1	0

(1) Side-by-side monitoring of H_2S in Trailer 023 and of SO_2 in Trailer 021 was initiated, as a data reliability check, for three months beginning 1 January, 1976. Therefore, no SO_2 data were taken at 023. The data from the second SO_2 analyzer at 021 are reported in the row for 023 for January, February, and March.

(2) Missing Data.

*All data below minimum detectable limit.

Table B-20

H_2S
Constituent

1 - HOUR MAXIMUM CONCENTRATIONS
(1974-1975)

By Month

Trailer	Item	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
020	Value (μg/m^3)	10.1	2.2	6.2	13.7	12.5	2.2	1.2	21.7	2.9	5.9	1.7	2.1
	Date	11/9	12/8	1/13	2/19	3/7	4/2	5/9	6/15	7/29	8/23	9/30	10/1
	Time (MST)	20:00	7:10	14:05	12:35	10:05	13:30	13:20	6:00	10:50	10:25	9:50	14:50
	Wind Direction (deg.)	111	104	174	186	190	208	225	130	201	230	288	345
	Wind Speed (MPH)	0	1	1	7	8	5	7	6	5	9	7	4
023	Value (μg/m^3)	3.2	45.3	28.4	8.2	19.1	6.5	6.9	8.0	71.2	38.5	15.1	1.8
	Date	11/12	12/21	1/1	2/26	3.7	4/14	5/1	6/25	7/9	8/20	9/4	10/28
	Time (MST)	5:40	1:55	11:10	6:05	18:55	6:55	6:35	18:05	0:10	4:40	7:45	11:45
	Wind Direction (Deg.)	123	156	315	156	165	113	238	316	57	257	15	277
	Wind Speed (MPH)	4	7	4	2	7	5	1	19	3	2	2	3
021	Value (μg/m^3)	58.9	4.6	4.7	9.5	7.3	4.3	9.0	13.8	3.5	8.3	6.9	13.8
	Date	11/18	12/7	1/31	2/7	3/21	4/26	5/9	6/16	7/8	8/17	9/3	10/13
	Time (MST)	1:25	8:00	4:35	17:10	21:30	23:20	1:30	11:40	1:40	12:35	0:05	3:05
	Wind Direction (Deg.)	123	337	138	163	117	350	151	294	143	219	119	58
	Wind Speed (MPH)	0	2	5	12	6	3	3	13	3	7	2	1
022	Value (μg/m^3)	4.7	8.4	2.4	14.3	14.1	10.1	1.3	11.9	5.7	4.3	3.8	11.9
	Date	11/18	12/8	1/25	2/28	3/1	4/11	5/28	6/15	7/14	8/23	9/1	10/22
	Time (MST)	9:35	0:40	14:25	20:55	0:00	14:00	9:15	19:45	12:55	9:55	9:25	23:00
	Wind Direction (Deg.)	126	69	275	72	102	34	267	57	139	286	186	283
	Wind Speed (MPH)	10	8.5	9	2	5	5	8	1	4	8	4	3
024	Value (μg/m^3)	8.3	7.7	27.6	8.1	8.5	62.5	56.9	70.9	3.0	8.5	10.4	20.9
	Date	11/5	12/24	1/10	2/17	3/23	4/14	5/2	6/22	7/29	8/30	9/7	10/8
	Time (MST)	15:55	1:55	16:45	13:10	2:40	0:35	1:40	19:05	11:55	11:50	2:15	2:20
	Wind Direction (Deg.)	268	154	201	258	89	197	120	232	244	183	124	201
	Wind Speed (MPH)	3	1	2	9	2	6	2	4	8	9	4	9

(1975-1976)

Trailer	Item	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
020	Value (μg/m^3)	2.0	.8	1.0	.2	5.0	30.9	2.3	0.7	1.0	1.2	1.2	3.8
	Date	11/10	12/12	1/24	2/15	3/8	4/5	5/25	6/6	7/5	8/30	9/16	10/27
	Time (MST)	9:25	2:05	11:05	8:55	10:15	15:55	21:30	9:00	4:25	10:05	4:25	2:45
	Wind Direction (Deg.)	229	57	CALM	115	310	295	118	179	108	89	86	85
	Wind Speed (MPH)	7	2		5	1	4	(2)	(2)	(2)	3	4	6
023	Value (μg/m^3)	6.9	10.0	20.5	7.4	3.5	7.1	6.8	9.0	7.4	13.0	5.2	8.3
	Date	11/29	12/6	1/10	2/11	3/5	4/26	5/6	6/17	7/30	8/5	9/29	10/4
	Time (MST)	8:50	8:50	15:15	14:55	4:55	13:50	6:40	6:05	14:20	9:55	3:00	4:15
	Wind Direction (Deg.)	140	57	7	202	CALM	211	292	128	311	14	184	202
	Wind Speed (MPH)	2	3	3	12		18	6.8	2	14	6	2	3
021	Value (μg/m^3)	4.6	2.8	4.4 (1)	3.7 (1)	5.5 (1)**	5.1	8.1	6.6	2.8	52.1	6.9	8.3
	Date	11/27	12/27	1/2	2/13*		4/18	5/25	6/6	7/9	8/19	9/30	10/9
	Time (MST)	9:40	11:25	8:20	21:35-22:50		5:00	21:15	9:20	4:40	8:10	13:25	8:15
	Wind Direction (Deg.)	126	248	100	195-179		CALM	88	133	82	135	236	317
	Wind Speed (MPH)	7	9	1	1-2			4	11	4	11	5	3
022	Value (μg/m^3)	1.4	2.0	(3)	.3	.3	7.1	2.8	1.4	6.5	(2)	(2)	(2)
	Date	11/25	12/14		2/26	3/13	4/22	5/1	6/10	7/7	(2)	(2)	(2)
	Time (MST)	14:05	10:35		9:55	11:55	10:55	0:00	4:20	4:00	(2)	(2)	(2)
	Wind Direction (Deg.)	304	271		113	114	219	107	90	116	(2)	(2)	(2)
	Wind Speed (MPH)	7	9		5	9	9	5	4	6	(2)	(2)	(2)
024	Value (μg/m^3)	1.3	8.2	9.8	.8	2.4	7.7	2.8	1.4	2.8	4.4	5.4	1.5
	Date	11/25	12/24	1/6	2/8	3/25	4/12	5/12	6/28	7/12	8/25	9/17	10/18
	Time (MST)	13:00	10:55	6:50	9:45	17:35	14:45	09:05	10:15	13:55	17:05	5:25	17:00
	Wind Direction (Deg.)	321	CALM	338	132	100	204	352	304	316	184	92	304
	Wind Speed (MPH)	10		1	7	2	13	11	3	15	4	4	3

(1) Side-by-side monitoring of H_2S in Trailer 023 and of SO_2 in Trailer 021 was initiated, as a data reliability check, for three months beginning 1 January, 1976. Therefore, no H_2S data were taken at 021 and the data from the second H_2S analyzer, at 023 are reported in the row for 021 for January, February, and March.

* Two maxima reported on same day.

** Maxima reported at 4 different times: 3/26 @ 22:15, 8mph. @ 146; 3/26 @ 23:20, 5mph. @ 118; 3/27 @ 0:25, 6mph. @ 136; 3/27 @ 2:40, 4mph. @ 101.

(2) Missing Data.

(3) All data below minimum detectable limit.

Methane HC
Constituent

Table B-21

3-HOUR MAXIMUM CONCENTRATIONS
(6-9 a.m.)
(1974-1975)

By Month

Trailer	Item	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
020	Value (μg/m^3)	933.2	1219.5	999.2	1298.0	998.9	(2) 837.8	924.0	862.5	859.2	1009.0	1068.1	968.2
	Date	11/9	12/8	1/12	2/3	3/15	4/28	5/2	6/2	7/31	8/14	9/18	10/9
	Wind Direction (Deg.)	77	111	118	278	317	124	172	125	334	110	124	123
	Wind Speed (MPH)	0	2	6	3	(3)	1	3	6	0	5	5	6
023	Value (μg/m^3)	(1) 96.7	(1) 1925.3	(1) 1137.7	900.1	910.2	902.4	903.9	879.1	879.4	979.5	1029.5	964.3
	Date	11/7	12/29	1/1	2/15	3/3	4/18	5/2	6/6	7/29	8/12	9/12	10/11
	Wind Direction (@ 30')	98	151	144	306	159	228	180	65	179	34	87	174
	Wind Speed (@ 30')	4	3	4	9	0	9	2	4	8	2	3	23

(1975-1976)

Trailer	Item	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
020	Value (μg/m^3)	NO	678.9	698.1	675.5	NO	598.1	571.0	1022.9	1045.0	1022.8	1063.7	1161.3
	Date		12/24	1/24	2/7		4/21	5/26	6/29	7/13	8/7	9/8	10/14
	Wind Direction (Deg.)	DATA	57	309	CALM	DATA	99	42	(3)	98	344	40	85
	Wind Speed (MPH)		1	2			2	(3)	(3)	(3)	3	1	3
023	Value (μg/m^3)	1172.8	1098.2	1075.1	1533.8	1170.4	1123.0	1092.5	1268.3	803.5	1122.9	1065.4	1064.7
	Date	11/12	12/14	1/11	2/21	3/14	4/27	5/13	6/24	7/13	8/6	9/8	10/29
	Wind Direction (Deg.)	115	312	140	203	182	84	77	55	75	141	257	177
	Wind Speed (MPH)	2	12	4	2	20	3	2	2	2	8	2	1

(1) Report data are incorrect because of contaminated manifold.
(2) Reported data may be incorrect because of malfunctioning instrument.
(3) Missing Data

Non-Methane HC
Constituent

Table B-22

3-HOUR MAXIMUM CONCENTRATIONS
(6-9 a.m.)
(1974-1975)

By Month

Trailer	Item	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
020	Value ($\mu g/m^3$)	197.6	179.7	223.8	51.4	288.6 (2)	707.7 (2)	83.5	141.2	69.6	42.1	319.4	486.9
	Time (MST)	11/25	12/19	1/12	2/25	3/31	4/22	5/2	6/21	7/7	8/4	9/3	10/28
	Wind Direction (Deg.)	127	101	117	107	128	130	172	68	93	336	122	89
	Wind Speed (MPH)	11	1	7	4	3	6	3	2	0	3	4	1
023	Value ($\mu g/m^3$)	17151.9 (1)	33269.7 (1)	2316 (1)	18.1	34.2	302.2	120.0	355.1 (2)	895.6 (2)	520.4	349.6	533.2
	Date	11/23	12/12	1/4	2/28	3/31	4/21	5/26	6/5	7/9	8/3	9/16	10/5
	Wind Direction (Deg.)	28	179	116	182	194	139?	281	22	131	61	139	85
	Wind Speed (MPH)	3	6	6	7	15	1	3	2	5	2	4	3

(1975-1976)

Trailer	Item	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
020	Value ($\mu g/m^3$)	NO	116.7	63.3	126.7	NO	58.6	39.8	98.2	177.4	98.2	452.4	126.1
	Date		12/5	1/24	2/11		4/24	5/27	6/26	7/13	8/1	9/7	10/18
	Wind Direction (Deg.)		139	307	93		134	47	288	98	81	46	70
	Wind Speed (MPH)	DATA	9	2	4	DATA	6	(3)	(3)	(3)	1	0	2
023	Value ($\mu g/m^3$)	590.0	286.7	553.3	926.7	560.0	1992.6	1816.4	2596.6	2520.0	1261.9	2236.4	298.9
	Date	11/13	12/5	1/1	2/26	3/31	4/29	5/1	6/27	7/3	8/6	9/5	10/29
	Wind Direction (Deg.)	126	105	264	148	163	288	81	62	51	141	61	177
	Wind Speed (MPH)	3	3	4	6	3	2	3	3	3	8	2	1

(1) Report data are incorrect because of contaminated manifold.
(2) Reported data may be incorrect because of malfunctioning instrument.
(3) Missing Data.

CO
Constituent

Table B-23
1 - HOUR MAXIMUM CONCENTRATIONS

(1974-1975)

By Month

Trailer	Item	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
020	Value (μg/m^3)	1353.8	1853.7	1700.8	1716.6(2)	3680.4(2)	1811.5(2)	3296.9(2)	4650.9(2)	2065.3(2)	1714.4	1376.7	2840.5
	Date	11/14	12/15	1/11	2/19	3/16	4/11	5/29	6/4	7/29	8/12	9/29	10/4
	Time (MST)	11:55	13:30	19:30	10:05	11:25	13:35	18:20	4:55	14:55	6:50	6:10	22:15
	Wind Direction (Deg.)	113	117	341	115	147	360	126	108	219	89	105	123
	Wind Speed (MPH)	0	1	6	5	12	5	6	1	5	0	3	4
023	Value (μg/m^3)	(1) 14563.1	(1) 5061.4	(1) 2563.2	769.7	2421.1	740.9	1155.9	790.8	1635.9	1097.3	2248.7	2474.7
	Date	11/14	12/19	1/23	2/3	3/24	4.26	5.27	6/26	7/9	8/16	9/23	10/9
	Time (MST)	15:25	4:50	17:15	15:05	13:20	7:20	17:15	22:10	11:50	15:45	10:00	6:35
	Wind Direction (Deg.)	210	246	214	202	206	39	96	114	175	350	295	115
	Wind Speed (MPH)	11	10	7	10	12	5	13	5	3	10	5	5

(1975-1976)

Trailer	Item	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
020	Value (μg/m^3)	NO DATA	501.4	568.1	NO DATA	NO DATA	NO DATA	1688.8	1244.5	1160.5	970.4	1058.2	952.8
	Date		12/30	1/24				5/20	6/1	7/25	8/25	9/14	10/1
	Time (MST)		0:35	11:05				15:55	10:35	13:30	1:05	20:35	6:50
	Wind Direction (Deg.)		CALM	CALM				CALM	CALM	107	118	92	39
	Wind Speed (MPH)									(3)	4	4	0
023	Value (μg/m^3)	3157.6	2032.9	3538.8	3009.1	1861.8	1972.3	2011.5	2746.6	(3)	(3)	(3)	(3)
	Date	11/26	12/11	1/6	2/27	3/22	4/5	5/13	6/12	(3)	(3)	(3)	(3)
	Time (MST)	1:20	11:00	13:20	21:55	22:25	14:20	8:10	12:55	(3)	(3)	(3)	(3)
	Wind Direction (Deg.)	CALM	221	302	123	125	158	25	221	(3)	(3)	(3)	(3)
	Wind Speed (MPH)		8	11	2	5	16	6	13	(3)	(3)	(3)	(3)

(1) Reported data are incorrect because of contaminated manifold.
(2) Reported data may be incorrect because of malfunctioning instrument. Data will be reported at a later date.

NO

Constituent

Table B-24

1-HOUR MAXIMUM CONCENTRATIONS (1974-1975) By Month

Trailer	Item	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
020	Value (μg/m^3)	44.3	16.4	43.7	7.8	4.7	27.1	34.0	29.8	3.1	38.1	26.5	34.2
	Date	11/10	12/9	1/22	2/19	3/19	4/26	5/25	6/1	7/31	8/17	9/4	10/13
	Time (MST)	5:50	7:05	7:30	9:35	19:15	14:30	2:35	8:55	22:20	1:55	23:10	3:35
	Wind Direction (Deg.)	131	106	105	126	122	235	9	294	129	132	101	101
	Wind Speed (MPH)	0	2	1	8	4	11	3	3	4	6	3	2
023	Value (μg/m^3)	38.5	93.9	114.2	52.6	16.7	10.1	4.2	28.7	15.3	17.0	16.5	9.0
	Date	11/28	12/24	1/17	2/9	3/17	4/27	5/8	6/28	7/13	8/16	9/14	10/18
	Time (MST)	8:10	1:05	9:55	9:25	11:40	7:25	11:40	3:25	4:30	23:20	20:05	1:00
	Wind Direction (Deg.)	303	263	116	179	9	328	295	240	83	88	93	132
	Wind Speed (MPH)	11	4	3	11	10	11	10	5	4	3	4	5

(1975-1976)

Trailer	Item	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
020	Value (μg/m^3)	27.8	37.8	37.8	30.9	44.3	64.1	78.6	62.3	30.6	26.7	244.0	170.2
	Date	11/3	12/30	1/17	2/27	3/2	4/26	5/25	6/17	7/1	8/31	9/27	10/4
	Time (MST)	5:15	3:00	21:25	3:55	7:30	1:50	22:55	18:35	16:25	5:15	7:25	6:55
	Wind Direction (Deg.)	114	137	136	135	CALM	13	112	125	288	99	35	98
	Wind Speed (MPH)	3	9	12	10		1	(1)	(1)	(1)	4	0	4
023	Value (μg/m^3)	4.1	25.0	1.4	15.4*	21.5	23.2	19.7	17.6	17.0	14.8	136.7	69.3
	Date	11/29	12/10	1/21	2/24-25	3/4	4/20	5/30	6/19	7/23	8/2	9/24	10/15
	Time (MST)	9:15	6:35	12:30	23:10-7:45	0:30	20:15	19:10	19:35	6:10	17:25	9:00	14:50
	Wind Direction (Deg.)	205	101	331	191 189	261	197	238	197	56	87	56	349
	Wind Speed (MPH)	2	3	2	2 5	2	10	7	7	2	7	1	8

(1) Missing Data
* Two maxima

NO_2

Constituent

Table B-25

1-HOUR MAXIMUM CONCENTRATIONS
(1974-1975)

By Month

Trailer	Item	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
020	Value (μg/m^3)	26.7	36.0	17.6	14.4	11.2	16.7	17.0	20.8	33.9	12.4	9.1	20.2
	Date	11/26	12/3	1/25	2/1	3/19	4/18	5/10	6/23	7/14	8/4	9/27	10/22
	Time (MST)	22:30	17:10	6:35	0:45	18:40	16:20	19:45	4:45	13:10	13:20	11:30	8:30
	Wind Direction (Deg.)	95	120	106	107	137	277	127	134	157	299	318	182
	Wind Speed (MPH)	3	0	4	2	5	11	4	7	1	5	6	9
023	Value (μg/m^3)	21.2	47.0	68.2	9.2	4.8	10.1	8.0	3.7	13.2	59.9	9.3	7.6
	Date	11/26	12/6	1/16	2/23	3/23	4/28	5/1	6/23	7/28	8/20	9/1	10/7
	Time (MST)	16:00	13:10	9:15	20:10	7:10	19:40	8:35	12:45	19:15	4:15	8:45	23:55
	Wind Direction (Deg.)	315	57	143	179	146	60	95	199	184	171	211	228
	Wind Speed (MPH)	7	5	4	4	4	6	5	11	11	2	12	10

(1975-1976)

Trailer	Item	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
020	Value (μg/m^3)	29.2	23.1	34.5	19.7	24.5	51.0	116.5	26.4	11.9	37.4	103.3	65.4
	Date	11/6	12/12	1/28	2/5	3/2	4/17	5/15	6/15	7/17	8/30	9/26	10/20
	Time (MST)	7:45	10:40	11:55	9:00	6:25	20:10	03:20	22:25	20:50	12:15	16:55	17:05
	Wind Direction (Deg.)	126	135	304	291	CALM	CALM	293	86	82	314	324	57
	Wind Speed (MPH)	6	5	2	8			10	(1)	(1)	4	5	2
023	Value (μg/m^3)	17.5	47.6	5.5	2.2	4.5	10.9	16.1	20.1	10.5	18.9	177.2	135.3
	Date	11/18	12/9	1/5	2/21	3/6	4/20	5/20	6/27	7/28	8/30	9/24	10/11
	Time (MST)	20:40	11:00	11:00	2:40	9:30	11:05	19.35	7:20	9:25	2:30	6:50	10:45
	Wind Direction (Deg.)	308	13	189	208	332	198	277	55	79	103	135	201
	Wind Speed (MPH)	13	2	11	1	2	5	6	3	3	4	4	13

(1) Missing Data

O_3

Constituent

Table B-26

1-HOUR MAXIMUM CONCENTRATIONS
(1974-1975)

By Month

Trailer	Item	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
020	Value ($\mu g/m^3$)	108.1	117.9	130.9	146	146.2	115.3	124.5	160.4	130.9	114.0	80.8	56.2
	Date	11/27	12/12	1/29	2/19	3/26	4/22	5/22	6/26	7/15	8/2	9/18	10/5
	Time (MST)	11:50	11:45	12:00	15:55	9:00	11:50	6:40	14:00	16:45	16:35	17:20	13:10
	Wind Direction (Deg.)	141	133	124	184	130	221	104	170	63	302	308	313
	Wind Speed (MPH)	(1)	0	4	7	4	9	3	6	0	8	12	5
023	Value ($\mu g/m^3$)	64.6	68.5	97.7	136	145.9	116.1	139.5	152.2	129.9	127.0	135.3	58.0
	Date	11/18	12/30	1/28	2/23	3/8	4/27	5/22	6/26	7/14	8/31	9/7	10/5
	Time (MST)	13:20	13:25	13:15	21:45	11:40	14:20	6:25	13:05	11:15	22:10	10:00	10:50
	Wind Direction (Deg.)	209	(1)	269	306	197	276	197	228	325	171	262	281
	Wind Speed (MPH)	20	2	12	3	15	9	3	10	5	7	5	8

(1975-1976)

Trailer	Item	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
020	Value ($\mu g/m^3$)	72.3	102.6	51.0	51.1	63.2	131.1	134.6	131.7	122.1	148.2	111.0	109.1
	Date	11/7	12/13	1/11	2/4	3/19	4/9	5/25	6/1	7/3	8/14	9/19	10/13
	Time (MST)	12:25	14:45	11:55	6:20	5:00	16:00	10:25	8:55	11:30	11:05	13:20	12:15
	Wind Direction (Deg.)	232	121	165	80	256	246	292	172	346	173	283	255
	Wind Speed (MPH)	9	4	5	11	7	10	(1)	(1)	(1)	9	5	7
023	Value ($\mu g/m^3$)	53.4	106.0	56.3	52.9	84.3	123.6	113.8	115.9	118.8	95.4	99.1	87.8
	Date	11/6	12/13	1/5	2/10	3/19	4/26	5/19	6/24	7/23	8/4	9/25	10/31
	Time (MST)	14:15	22:50	3:55	0:20	5:10	14:05	11:05	11:55	22:15	16:05	14:40	1:40
	Wind Direction (Deg.)	230	316	149	214	226	205	13	209	137	206	(1)	90
	Wind Speed (MPH)	13	12	3	22	19	19	4	8	15	13	7	0

(1) Missing Data

Table B-27

MONTHLY AND ANNUAL AVERAGE AMBIENT AIR CONSTITUENT CONCENTRATIONS OF GASES AND PARTICULATES ($\mu g/m^3$)

1974-1975

Trailer	Item	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Annual Average
020	NO ($\mu g/m^3$)	1.9	0.7	3.4	*0.4	*0.3	9.6	17.8	*3.2	*0.4	9.1	*3.2	3.5	5.8
023		4.4	*12.8	14.7	0.4	*1.2	0.6	0.1	0.3	0.6	1.4	0.6	0.3	2.4
020	NO_2 ($\mu g/m^3$)	2.8	6.8	4.5	*2.5	*1.2	2.7	4.1	*0.3	*1.7	4.7	*3.0	7.9	4.1
023		2.4	*4.7	7.4	0.2	*0.4	0.9	0.5	0.0	1.5	1.0	0.1	0.7	1.5
020	O_3 ($\mu g/m^3$)	58.0	69.3	93.7	105.1	88.0	77.1	71.5	69.1	74.6	50.8	41.1	32.8	68.8
023		*31.4	28.0	42.4	85.8	85.6	90.5	87.3	84.4	86.1	61.0	53.4	43.3	68.0
020	Non-Methane H.C. ($\mu g/m^3$)	73.4	97.4	*75.7	23.4	38.6	327.6(2)	38.9	50.8	25.8	27.9	58.9	75.9	74.3
023		933.0(1)	20213.6(1)	*662.8(1)	22.1	*17.1	49.1	43.3	196.5	220.2	145.6	92.2	331.8	130.8
020	CH_4 ($\mu g/m^3$)	826.1	918.8	*908.1	879.4	829.8	590.6(2)	833.6	821.2	825.9	908.8	949.3	935.6	851.7
023		825.5	1053.8(1)	*943.6(1)	*833.7	*859.8	836.3	834.3	814.7	780.7	902.7	933.4	814.1	849.0
020	CO ($\mu g/m^3$)	553.8	676.9	908.2	1228.5(2)	1498.0(2)	*853.0(2)	1815.5(2)	1092.1(2)	206.5(2)	237.5	775.8	2514.6	1080.0
023		3703.6(1)	2439.3(1)	1786.2(1)	391.4	504.5	485.8	699.9	437.0	468.5	511.0	827.9	(3)	1114.1
020	SO_2 ($\mu g/m^3$)	0	1.8	0	0.1	1.1	0.1	0	1.0	1.6	0.9	0.7	1.4	.8
021		1.3	1.7	0.8	0.8	0.6	1.2	1.1	2.1	1.3	1.9	1.7	1.8	1.3
022		2.6	0.1	0	0.2	0	0	0.5	1.7	0.4	0.6	0	0.6	.5
023		0	6.4	3.3	0.1	0.6	0.5	0	0.0	0.6	2.0	0.9	0.2	1.0
024		0.2	1.7	1.3	5.5	0.9	1.1	0.7	0.6	0.1	0.9	0.7	2.0	1.3
020	H_2S ($\mu g/m^3$)	0	0	0	0	0.4	0	0	0.2	0	0	0.1	0.1	.1
021		1.6	0	0.2	0.8	0.4	0.2	0.4	0.7	0.2	0.4	0.7	0.8	.6
022		0.2	1.2	0	0.2	0.3	0.7	0	0.4	0.2	0.3	0.4	0.2	.3
023		0	5.2	2.5	0.7	2.7	0.5	0.3	0.3	4.8	2.4	2.1	0	1.7
024		0	0.1	0	0.2	0.4	1.0	0.3	1.1	0.1	0.1	0.6	1.0	.4
020	Particulate ($\mu g/m^3$)	*48.7(3)	4.3	3.3	3.8	6.5	11.6	12.4	10.7	14.7	17.9	12.8	11.2	13.2
021		*20.4	5.4	4.0	4.5	6.9	13.7	13.2	12.3	15.6	13.9	12.4	12.4	11.2
022		*35.3	4.2	2.9	3.2	5.3	11.9	11.2	9.5	14.6	11.5	12.6	9.7	11.0
023		*18.0	*6.8	*2.5	4.2	11.5	15.4	19.3	18.3	14.4	12.1	11.1	13.7	12.7
024		*117.0	2.9	2.3	3.8	4.9	10.2	11.4	8.7	11.3	13.1	9.8	12.4	

1975-1976

Trailer	Item	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Annual Average
020	NO ($\mu g/m^3$)	2.6	3.4	12.5	5.7	(3)	(3)	(3)	(3)	4.9	(3)	55.1	(3)	14.0
023		.0**	2.5	0.0*	(3)	2.0	.4	1.5	2.2	1.2	2.6	3.9	4.5	2.1
020	NO_2 ($\mu g/m^3$)	8.5	2.2	4.8	2.1	(3)	(3)	(3)	(3)	(3)	(3)	7.4	(3)	5.0
023		.8	2.6	(3)	(3)	.1	0.3	1.3	1.5	.2	1.6	2.2	4.4	1.5
020	O_3 ($\mu g/m^3$)	30.9	32.7	35.7	30.7	40.2	66.5	72.7	66.3	69.8	74.4	55.9	55.0	52.6
023		39.2	38.2	37.1	41.2	45.2	68.0	78.4	74.5	81.5	58.8	55.5	57.4	56.3
020	Non Methane H.C. ($\mu g/m^3$)	No Data	26.4	20.5	(3)	(3)	(3)	(3)	60.3	77.6	26.5	83.5	79.6	53.5
023		303.8	151.3	171.2	389.7	388.7	818.3	1194.6	1687.9	(3)	(3)	452.2	153.2	571.1
020	CH_4 ($\mu g/m^3$)	No Data	579.5	592.5	(3)	(3)	(3)	533.1	928.9	958.4	977.4	954.7	1066.0	823.8
023		920.6	909.6	862.5	1046.6	1046.6	1007.2	948.0	974.5	(3)	(3)	953.7	942.2	962.6
020	CO ($\mu g/m^3$)	No Data	(3)	408.5	(3)	(3)	(3)	1294.8	562.8	444.0	439.9	561.0	526.4	605.4
023		1847.3	(3)	1787.3*	1161.8	1271.5	657.0	(3)	1821.5	(3)	(3)	(3)	(3)	1351.8
020	SO_2 ($\mu g/m^3$)	.0	.0	.0	.0	.0	.0	1.1	1.1	.4	.0	.9	.6	.3
021		.9	.0	1.7	.2	.6	.8	1.3	(3)	(3)	(3)	(3)	.4	.7
022		.1	1.4	1.9	1.7	1.4	1.0	0.5	.0	.7	.1	.2	(3)	.8
023		.0	.2	1.1(4)	.1(4)	2.6(4)	.5	0.6	.3	.1	.1	.7	.6	.6
024		1.1	.8	.2	.1	.2	.3	0.5	1.1	.8	6.2	(3)	1.5	1.2
020	H_2S ($\mu g/m^3$)	.1	.0	.0	.0	.1	.3	.0	.0	.0	.0	.0	.0	.0
021		.1	.2	0.2(4)	.1(4)	.1(4)	.7	.6	.8	.0	.6	.6	1.2	.4
022		.0	.1	.0	.0	.0	.6	.2	.1	(3)	(3)	(3)	(3)	.1
023		.4	.9	3.3	.9	.4	.3	.6	7.	.1	.4	.4	.4	.7
024		.0	.1	.4	.0	.0	.0	.0	.0	.1	.7	.5	.1	.2
020	Particulate ($\mu g/m^3$)	5.0	2.8	3.2	3.2	7.5	14.7	10.5	12.5	17.9	10.8	8.9	10.1	8.9
021		4.3	3.7	3.4	2.7	6.9	14.0	10.3	13.3	16.7	11.2	9.2	10.2	8.8
022		4.6	2.8	3.3	2.6	5.7	12.5	7.6	10.3	11.6	8.4	7.9	6.2	7.0
023		3.9	2.3	2.8	2.4	5.5	9.8	8.9	11.4	13.4	9.3	7.2	7.1	7.0
024		5.3	2.5	3.3	3.0	7.5	14.4	10.2	14.2	16.4	10.2	8.1	6.7	8.5

(1) Reported data are incorrect because of contaminated manifold.
(2) Reported data may be incorrect because of possible malfunctioning instrument.
(3) Few or no data collected because of instrument malfunction.
(4) Side-byside monitoring of H_2S in Trailer 023 and of SO_2 in Trailer 021 was initiated as a data reliability check for three months beginning 1 January, 1976. Therefore, no SO_2 data were taken at 023 and no H_2S data were taken at 021. The data from the second SO_2 analyzer at 021 are reported in the row for 023 for January, February and March. Data from the second H_2S analyzer at 023 are reported in the row for 021 for January, February and March.

* 50% or Less Data
** .0 indicates below limits of detectability of the recording instruments.

The following tables support subsection 3.2.5, SO_2 and H_2S Side-by-Side Tests:

(Note: H_2S differences for February, March were approximately zero.

Table B-28

TABLE OF DIFFERENCES IN SO_2 IN SIDE-BY-SIDE TESTS
PERFORMED AT STATION 021
a. JANUARY 1976

MO	DA	HOUR 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	MEAN	S DEV
1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	****	0.0	0.0
1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
1	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
1	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
1	5	0	0	0	0	0	0	0	-16	28	0	0	-50	-30	0	0	0	0	0	0	0	0	0	0	0	-2.8	13.6
1	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
1	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
1	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
1	9	0	0	0	0	0	0	0	0	0	0	0	0	****	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
1	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
1	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
1	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
1	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
1	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
1	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
1	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
1	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
1	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
1	19	0	0	0	0	0	0	0	0	0	0	0	0	0	****	0	0	0	0	0	0	0	0	0	0	0.0	0.0
1	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
1	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
1	22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
1	23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
1	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
1	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
1	26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
1	27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
1	28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
1	29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
1	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
1	31	0	0	0	0	0	0	0	0	0	0	****	15	0	0	0	0	0	0	0	0	-18	-29	-34	****	-3.0	10.6
MEAN		0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.5	0.9	0.0	0.0	-1.1	-1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.6	-0.9	-1.1	0.0	-.1813	
STD DEV		0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.9	5.0	0.0	0.0	9.5	5.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.2	5.2	6.1	0.0		3.0714

TOTAL NO. OF OBSERVATIONS 739.
NOTE: MISSING DATA CODE IS ****

Table B-29

TABLE OF DIFFERENCES IN SO_2 SIDE-BY-SIDE TESTS
PERFORMED AT STATION 021
b. FEBRUARY 1976

MO	DA	HOUR 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	MEAN	S DEV
2	1	****	****	****	0	0	0	0	0	0	0	0	****	****	****	****	****	****	****	****	****	****	****	****	****	0.0	0.0
2	2	****	****	****	****	****	****	****	****	****	****	****	****	****	****	0	0	0	0	0	0	0	0	0	0	0.0	0.0
2	3	0	0	0	0	0	0	0	0	0	0	****	****	****	****	0	0	0	0	0	0	0	0	0	0	0.0	0.0
2	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
2	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
2	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
2	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
2	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
2	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
2	10	0	0	0	0	0	0	0	0	0	0	0	0	****	****	****	****	****	****	****	****	****	****	****	****	0.0	0.0
2	11	****	****	****	****	****	****	****	****	****	****	****	****	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
2	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
2	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
2	14	0	0	0	0	0	0	0	0	0	0	****	****	****	****	****	****	****	****	****	****	****	****	****	****	0.0	0.0
2	15	****	****	****	****	****	****	****	****	****	****	****	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
2	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
2	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
2	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
2	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
2	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
2	21	0	0	0	0	0	0	0	0	0	0	0	****	****	****	****	****	****	****	****	****	****	****	****	****	0.0	0.0
2	22	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	0.0	0.0
2	23	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	0.0	0.0
2	24	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	0.0	0.0
2	25	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	0.0	0.0
2	26	****	****	****	****	****	****	****	****	****	****	****	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
2	27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
2	28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
2	29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
MEAN		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
STD DEV		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0

TOTAL NO. OF OBSERVATIONS 493.
NOTE: MISSING DATA CODE IS ****

Table B-30

TABLE OF DIFFERENCES IN SO_2 IN SIDE-BY-SIDE TESTS
PERFORMED AT STATION 021
c. MARCH 1976

MO	DA	HOUR 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	MEAN	S DEV
3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
3	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	****	0.0	0.0
3	5	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	0.0	0.0
3	6	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	0.0	0.0
3	7	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	0.0	0.0
3	8	****	****	****	****	****	****	****	****	****	****	****	****	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
3	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
3	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
3	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
3	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
3	13	0	0	0	0	0	0	0	0	0	0	0	0	19	19	15	0	0	0	0	16	16	17	15	15	5.5	8.0
3	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
3	15	0	0	0	0	0	0	0	13	15	15	13	****	****	****	****	****	****	****	****	****	****	****	****	****	5.1	7.1
3	16	****	****	****	****	****	****	****	****	****	****	****	****	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
3	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
3	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
3	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
3	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
3	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	****	****	****	0.0	0.0
3	22	****	****	****	****	****	****	****	****	****	****	****	0	-14	-33	-52	-54	-52	-49	-45	-37	-37	-33	-29	-27	-35.5	15.8
3	23	-21	-20	-19	-19	-20	-21	-21	-21	-22	0	0	0	0	0	0	0	0	0	-13	-16	-19	-23	-24	-27	-12.8	10.4
3	24	-26	-26	-26	-24	-23	-23	-21	-20	-17	-16	-13	0	0	0	0	0	0	0	0	0	0	0	0	0	-9.8	11.3
3	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
3	26	0	0	0	0	0	0	-15	-18	-19	-20	0	-13	-21	-21	-19	-23	-13	0	0	0	-13	-14	-13	0	-9.3	9.1
3	27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	****	****	****	****	****	0.0	0.0
3	28	****	****	****	****	****	****	****	****	****	****	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
3	29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
3	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
3	31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
MEAN		-2.0	-1.9	-1.9	-1.8	-1.8	-1.8	-2.4	-1.9	-1.8	-0.9	0.0	-0.5	-0.6	-1.3	-2.1	-2.9	-2.4	-1.8	-2.1	-1.4	-2.0	-2.1	-2.0	-1.6	-1.7140	
STD DEV		6.7	6.6	6.4	6.1	6.1	6.2	6.5	7.4	7.5	6.1	3.8	2.6	6.2	8.4	11.0	11.1	10.2	9.4	8.9	8.6	9.0	9.1	8.4	8.4		7.7419

TOTAL NO. OF OBSERVATIONS 605.
NOTE: MISSING DATA CODE IS ****

Table B-31

TABLE OF DIFFERENCES IN H_2S IN SIDE-BY-SIDE TESTS
PERFORMED AT STATION 023
JANUARY 1976

MO	DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Mean	Std. Dev.
														HOUR													
1	1	0	0	0	0	0	0	0	0	0	0	0	0	****	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
1	2	0	0	0	0	0	0	0	0	0	0	0	0	****	****	****	****	****	****	****	****	****	****	****	****	0.0	0.0
1	3	****	****	****	****	****	****	****	****	****	****	****	****	****	****	0	0	0	0	0	0	0	0	0	0	0.0	0.0
1	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
1	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	11	13	15	18	2.8	5.7
1	6	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4	2.0
1	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	****	****	****	****	****	****	0.0	0.0
1	8	****	****	****	****	****	****	****	****	****	****	****	****	9	10	0	0	0	0	0	0	0	0	0	0	1.6	3.7
1	9	0	0	0	8	9	8	7	0	0	0	0	****	0	0	0	0	0	0	0	0	0	0	0	0	1.4	3.1
1	10	0	0	0	0	0	0	0	0	7	9	10	12	14	16	18	19	18	8	0	0	0	0	0	0	5.5	7.2
1	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	****	****	****	****	****	****	****	****	****	0.0	0.0
1	12	****	****	****	****	****	****	****	****	****	****	****	****	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
1	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
1	14	0	0	0	0	0	0	0	0	0	0	0	0	7	0	7	8	7	8	8	8	8	0	0	0	2.5	3.7
1	15	0	0	0	0	0	0	7	7	7	8	8	7	11	11	10	10	10	10	9	10	8	9	10	11	6.8	4.2
1	16	11	12	13	14	13	13	13	14	13	14	18	13	8	8	10	9	11	12	10	8	7	11	13	15	11.8	2.6
1	17	15	15	15	14	11	9	5	10	11	12	12	13	13	12	12	12	12	12	13	13	13	14	14	15	12.4	2.2
1	18	15	15	17	17	11	****	9	9	7	7	0	0	0	0	0	0	0	8	7	0	0	9	13	17	7.0	6.5
1	19	16	10	0	0	0	****	0	0	0	0	0	0	0	****	0	0	0	7	8	8	8	8	8	8	3.7	4.8
1	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	10	12	14	14	14	9	0	0	0	3.3	5.5
1	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	10	13	14	0	0	0	0	0	0	1.8	4.3
1	22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	9	10	1.1	3.0
1	23	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	1.4
1	24	0	0	0	0	0	0	0	0	0	0	0	****	****	****	****	****	****	****	****	****	****	****	****	****	0.0	0.0
1	25	****	****	****	****	****	****	****	****	****	****	****	****	0	0	0	0	0	0	0	0	0	0	0	7	0.6	2.0
1	26	9	11	12	13	14	13	9	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	3.8	5.6
1	27	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	1.4
1	28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
1	29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	****	****	****	****	****	****	****	0.0	0.0
1	30	****	****	****	****	****	****	****	****	****	****	****	****	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
1	31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
Mean		3.5	2.4	2.2	2.5	2.2	1.8	1.9	1.5	1.7	1.9	1.8	1.8	2.3	2.1	2.4	3.1	3.0	3.6	2.7	2.7	2.5	2.7	3.2	3.9	2.2	
Std. Dev.		5.6	5.1	5.3	5.5	4.7	4.2	3.8	3.8	3.8	4.2	4.7	4.3	4.5	4.7	4.8	5.4	5.5	5.2	4.6	4.7	4.3	4.8	5.5	6.3		3.3

Total No. of Observations 632

Note: Missing Data Code is ****

Difference tables for February and March, 1976 are not shown as there was only one observation above the detection limit in February and none in March.

B.2.2 Particulate Concentrations

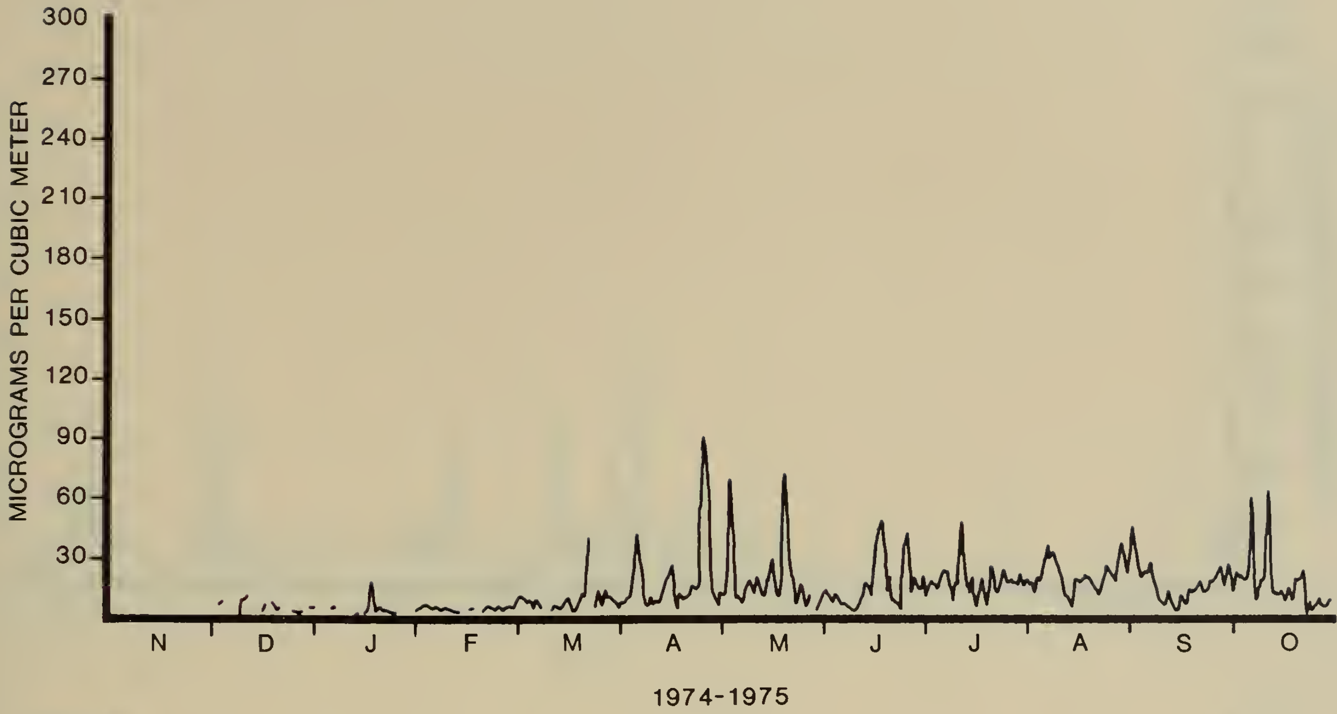
The following figures and tables support subsection 3.2.2.5.1, Particulate Concentrations:

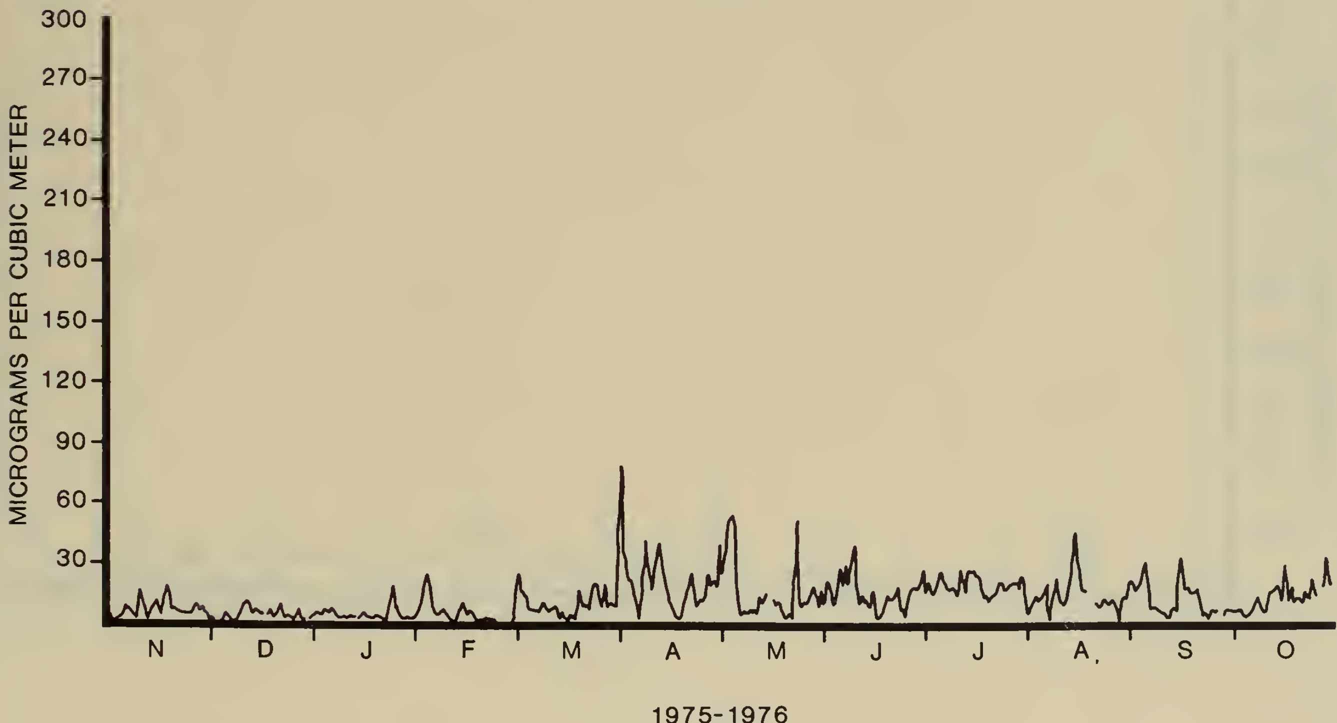
	Two Annual Time Series of 24-Hour Concentrations of Particulates
Figure B-31a	Station 020
Figure B-31b	Station 021
Figure B-31c	Station 022
Figure B-31d	Station 023
Figure B-31e	Station 024
Table B-32	Ten Highest 24-Hour Particulate Averages
Table B-33	24-Hour Maximum Particulate Concentrations by Month

The following figures and tables support subsection 3.2.2.5.2, Particulate Concentration Correlations:

Table B-34	Computer Output - Multiple Linear Regressions for Particulate Concentrations. This program is discussed in Section B.2.3. Data inputs are given in Table 3-16.
Figure B-32	Correlation of Daily Mean Particulates Concentration with Daily Mean Wind Speed
Figure B-33	Correlation of Daily Mean Particulates Concentration with Daily Mean Wind Speed Squared
Figure B-34	Correlation of Daily Mean Particulates Concentration with Daily Mean Speed Cubed
Figure B-35	Correlation of Daily Mean Particulates Concentration with Max. Wind Speed Cubed

Note: Figures 3-19 and 3-20 present the correlation of daily mean particulates concentration with max. wind speed and max. wind speed squared.



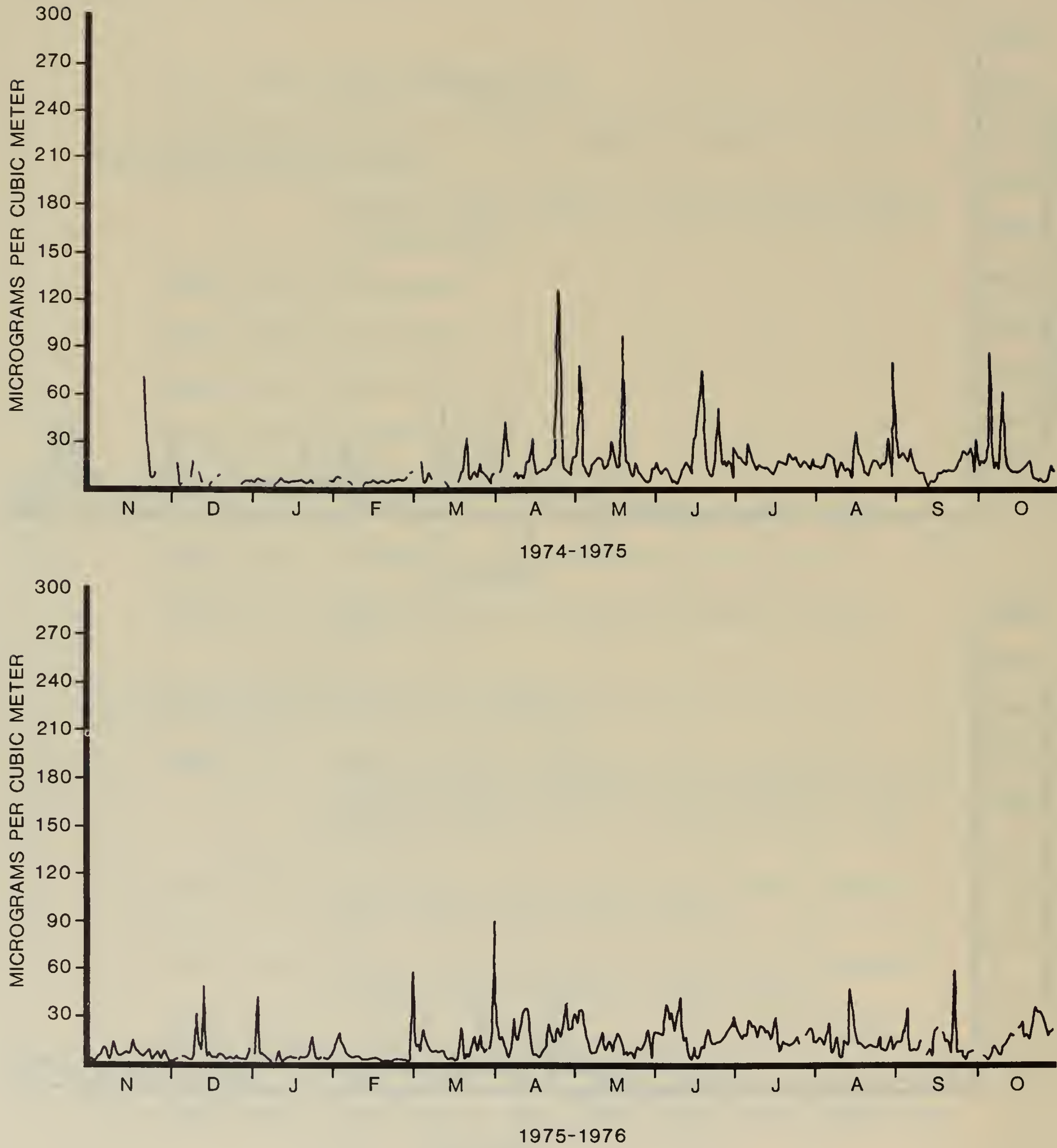


STATION 020

TWO ANNUAL TIME SERIES

OF 24 HOUR CONCENTRATIONS OF PARTICULATES

FIGURE B-31a

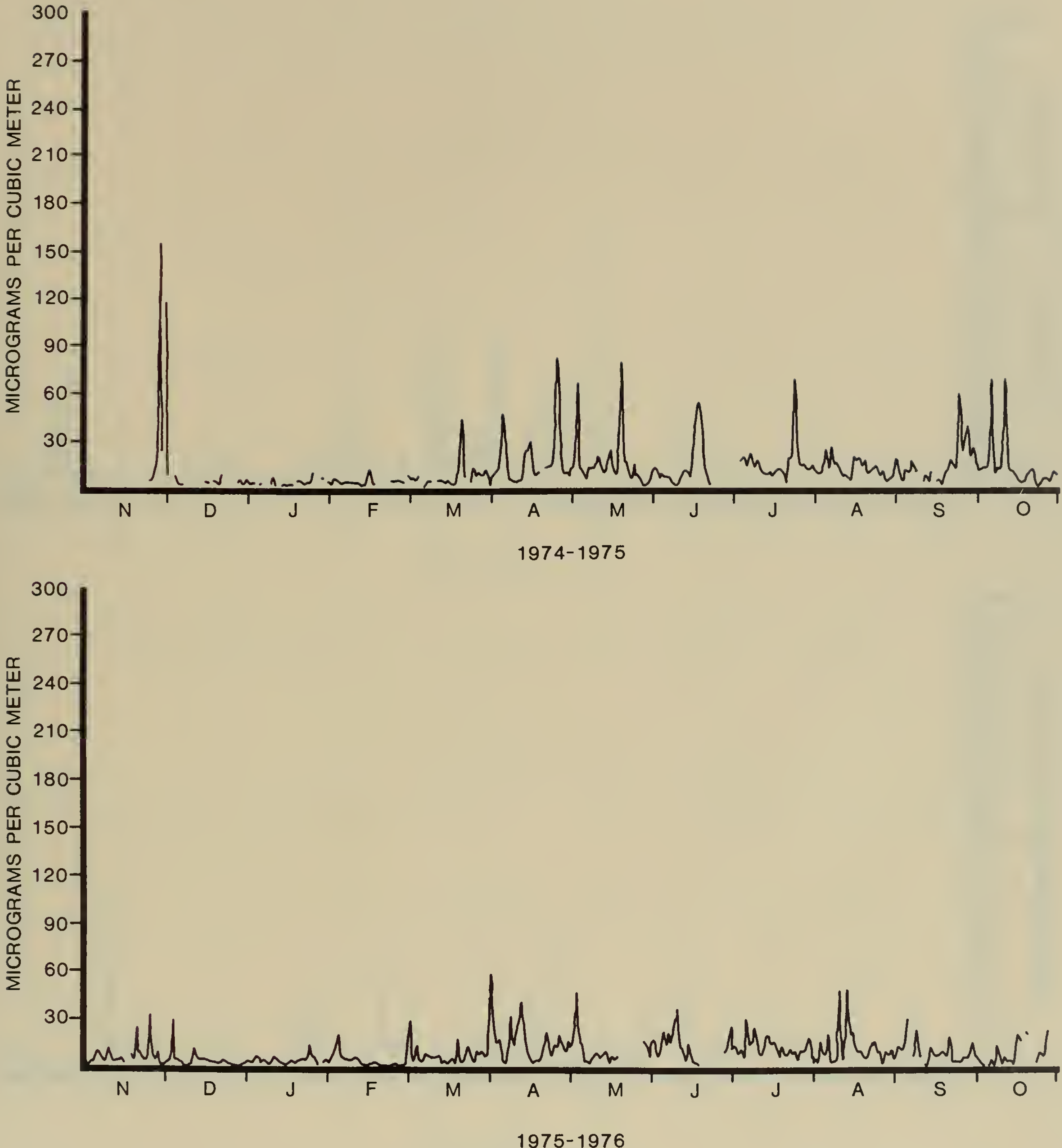


STATION 021

TWO ANNUAL TIME SERIES

OF 24 HOUR CONCENTRATIONS OF PARTICULATES

FIGURE B-31b

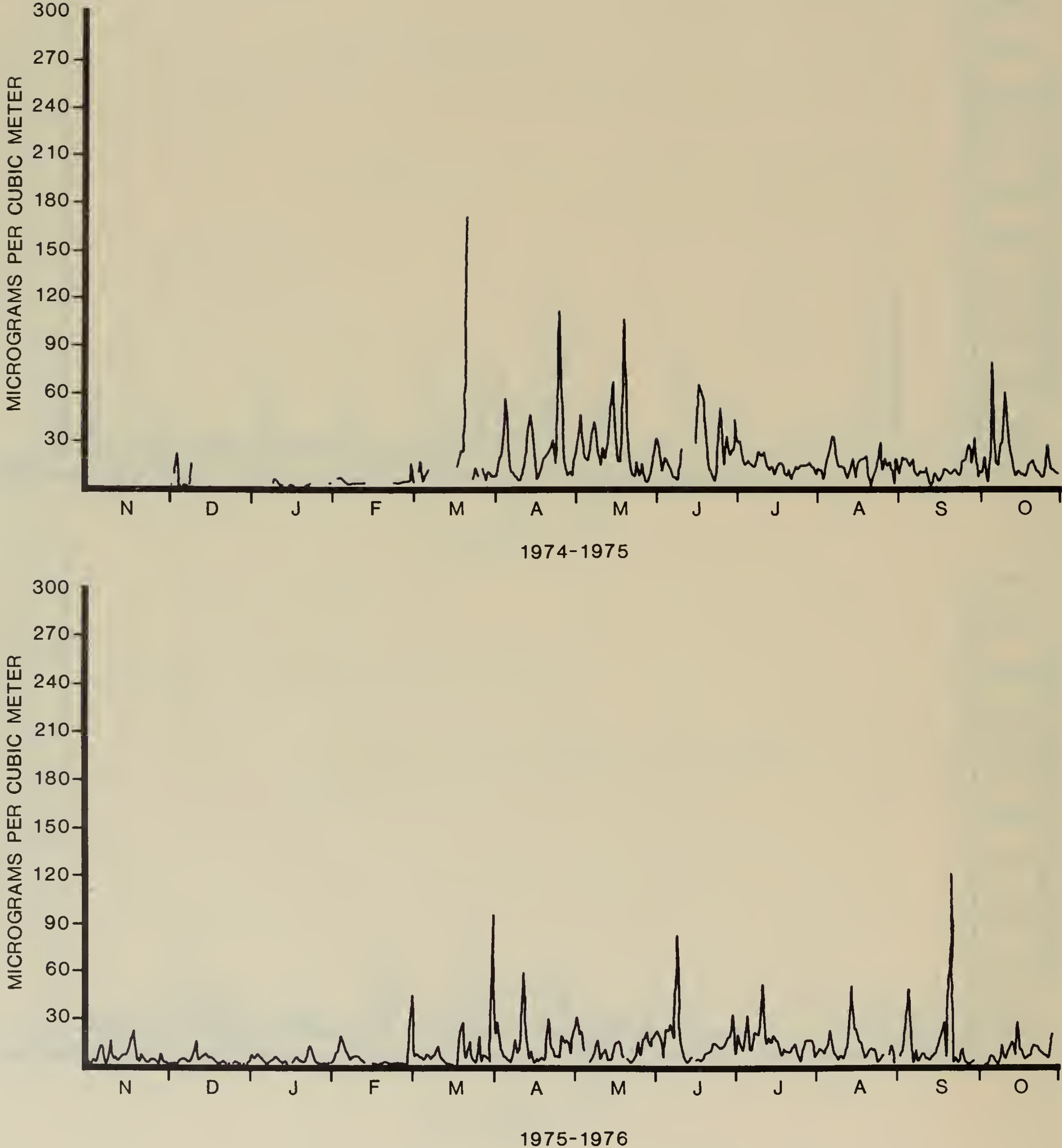


STATION 022

TWO ANNUAL TIME SERIES

OF 24 HOUR CONCENTRATIONS OF PARTICULATES

FIGURE B-31c

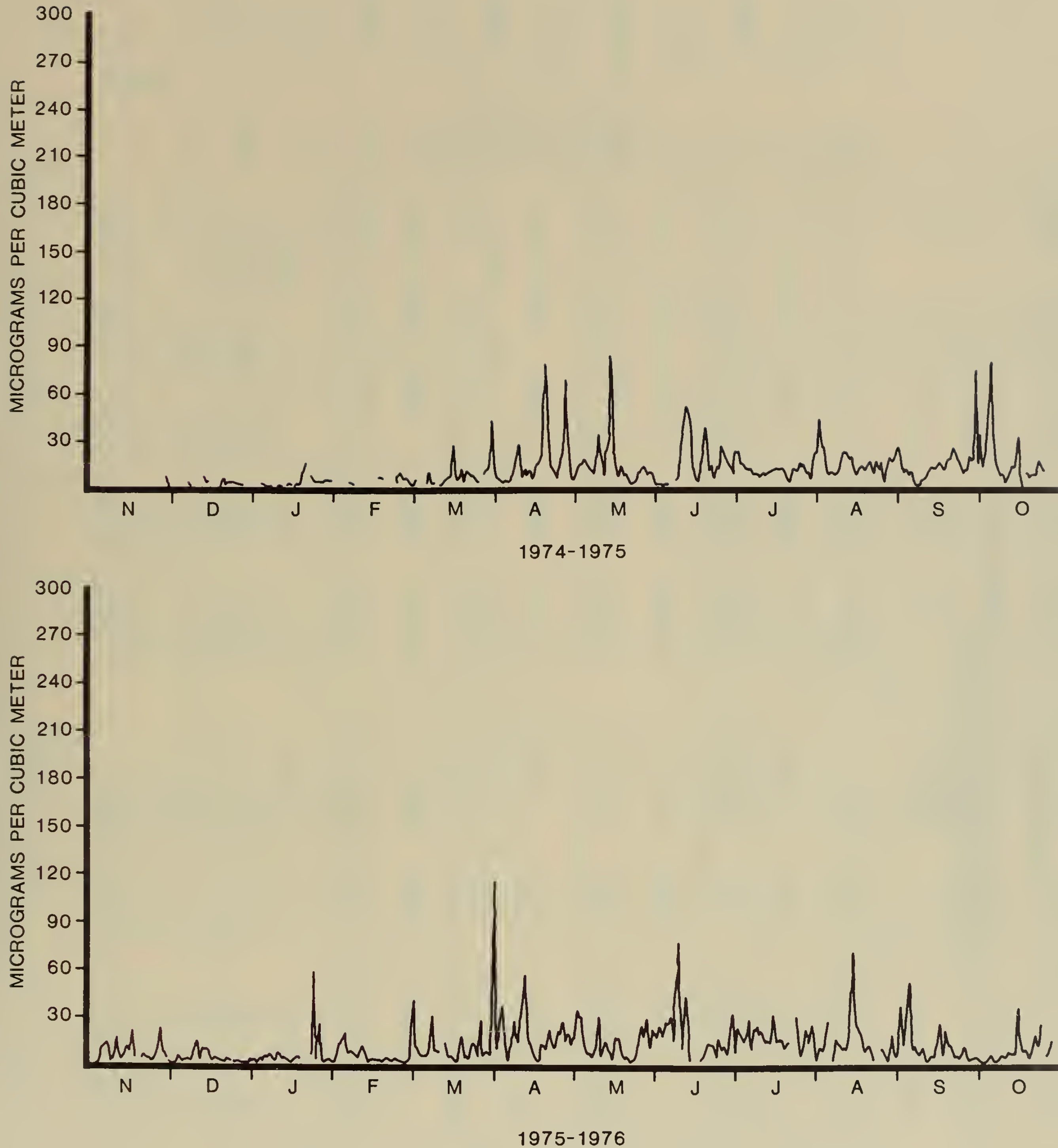


STATION 023

TWO ANNUAL TIME SERIES

OF 24 HOUR CONCENTRATIONS OF PARTICULATES

FIGURE B-31d



STATION 024

TWO ANNUAL TIME SERIES

OF 24 HOUR CONCENTRATIONS OF PARTICULATES

FIGURE B-31 e

Table B-32

TEN HIGHEST TWENTY-FOUR HOUR PARTICULATE
AVERAGES DURING BASELINE
($\mu g/m^3$)

Site	1	2	3	4	5	6	7	8	9	10
020 Concentration	113.0	89.0	79.0	70.0	69.0	62.0	59.0	55.0	53.0	51.0
Date	11/29/74	4/25/75	4/2/76	5/20/75	5/4/75	10/12/75	10/7/75	5/5/75	5/4/76	5/24/76
021 Concentration	125.0	97.0	90.0	87.0	81.0	77.0	75.0	71.0	64.0	62.0
Date	4/25/75	5/20/75	4/2/76	10/7/75	9/1/75	5/4/75	6/19/75	11/21/75	4/26/75	10/12/74
022 Concentration	154.0	116.0	82.0	80.0	70.0	70.0	69.0	68.0	60.0	60.0
Date	11/28/74	12/1/74	4/25/75	5/20/75	10/7/75	10/12/75	7/24/75	5/4/75	9/24/75	4/2/76
023 Concentration	171.0	123.0	112.0	107.0	96.0	82.0	81.0	67.0	65.0	62.0
Date	3/22/75	9/21/76	4/25/75	5/20/75	4/2/75	6/10/76	10/7/75	5/16/75	6/17/75	6/18/75
024 Concentration	178.0	162.0	116.0	86.0	80.0	80.0	77.0	75.0	72.0	69.0
Date	11/27/74	11/29/74	4/2/76	5/20/75	4/25/75	10/12/75	6/10/76	10/6/75	8/15/76	5/4/75

Particulate Constituent

Table B-33

24 - HOUR MAXIMUM CONCENTRATIONS

Midnight - Midnight (1974-1975) By Month

Trailer	Item	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
020	Value (μg/m³)	133.0	11.0	17.0	11.0	39.0	89.0	70.0	48.0	47.0	49.0	44.0	62.0
	Date	11/29	12/12	1/18	2/27	3/22	4/25	5/20	6/18	7/12	8/29	9/2	10/12
	(1)24-hr. ave. Wind Direction (Deg)	121	107	117	124	195	170	236	119	60	144	50	167
	Max. 1-hr. ave. Wind Speed (MPH)	5	8	8	5	14	24	20	12	6	8	8	15
	Wind Speed - 24-hr. ave. (MPH)	2	3	5	4	7	15	10	6	4	5	4	8
023	Value (μg/m³)	26.0	22.0	6.0	11.0	171.0	112.0	107.0	65.0	42.0	31.0	33.0	81.0
	Date	11/27	12/4	1/11	2/27	3/22	4/25	5/20	6/17	7/1	8/7	9/29	10/7
	(1)24-hr. ave. Wind Direction	174	171	313	192	226	186	234	215	188	210	260	188
	Max. 1-hr. ave. Wind Speed	15	18	16	5	38	41	34	23	18	20	18	30
	Wind Speed - 24-hr. ave.	7	10	8	4	16	27	17	11	9	11	7	16
021	Value (μg/m³)	71.0	18.0	7.0	10.0	32.0	125.0	97.0	75.0	28.0	37.0	81.0	87.0
	Date	11/21	12/10	1/13	2/28	3/22	4/25	5/20	6/19	7/7	8/17	9/1	10/7
	(1)24-hr. ave. Wind Direction	114	102	4	140	170	168	327	143	56	144	129	124
	Max. 1-hr. ave. Wind Speed	10	9	6	8	20	28	21	14	9	8	14	21
	Wind Speed - 24-hr. ave.	4	4	3	4	9	14	12	9	4	5	7	8
022	Value (μg/m³)	154.0	116.0	10.0	12.0	44.0	82.0	80.0	55.0	69.0	27.0	60.0	70.0
	Date	11/28	12/1	1/26	2/12	3/21	4/25	5/20	6/18	7/24	8/6	9/24	10/7
	(1)24-hr. ave. Wind Direction	290	137	112	116	168	136	183	121	354	104	106	126
	Max. 1-hr. ave. Wind Speed	9	9	12	12	9	16	15	8	11	14	10	12
	Wind Speed - 24-hr. ave.	5	5	5	7	5	13	9	5	7	8	7	8
024	Value (μg/m³)	178.0	8.0	16.0	9.0	27.0	80.0	86.0	52.0	27.0	30.0	26.0	80.0
	Date	11/27	12/5	1/27	2/28	3/22	4/25	5/20	6/18	7/2	8/8	9/7	10/12
	(1)24-hr. ave. Wind Direction	118	261	248	130	196	180	235	205	141	38	204	186
	Max. 1-hr. ave. Wind Speed	8	7	5	8	33	37	30	18	21	14	7	25
	Wind Speed - 24-hr. ave.	4	2	3	4	13	22	14	9	6	5	5	15

(1975-1976)

Trailer	Item	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
020	Value (μg/m³)	20.0	11.0	19.0	25.0	25.0	79.0	55.0	39.0	27.0	45.0	33.0	33.0
	Date	11/18	12/12	1/25	2/4	3/2	4/2	5/5	6/11	7/15	8/15	9/16	10/29
	(1) 24-hr. ave. Wind Direction (Deg)	354	119	111	124	271	42	82	186	32	133	117	85
	Max. 1-hr. ave. Wind Speed (MPH)	11	12	8	14	9	7	8	(2)	(2)	17	10	7
	Wind Speed - 24-hr. ave. (MPH)	5	7	4	9	3	4	3	(2)	(2)	9	5	5
023	Value (μg/m³)	23.0	16.0	13.0	19.0	45.0	96	32.0	82.0	53.0	51.0	123.0	29.0
	Date	11/18	12/12	1/24	2/4	3/2	4/2	5/3	6/10	7/12	8/15	9/21	10/17
	(1) 24-hr. ave. Wind Direction	245	168	273	173	239	260	188	184	181	183	234	147
	Max. 1-hr. ave. Wind Speed	19	24	14	32	16	11	13	25	17	29	15	22
	Wind Speed - 24-hr. ave.	10	13	6	17	9	5	7	16	8	17	6	14
021	Value (μg/m³)	15.0	50.0	42.0	21.0	59.0	90	34.0	42.0	28.0	47.0	59.0	35.0
	Date	11/10	12/14	1/4	2/4	3/2	4/2	5/4	6/11	7/17	8/15	9/23	10/24
	(1) 24-hr. ave. Wind Direction	102	300	350	116	279	78	128	152	92	126	91	61
	Max. 1-hr. ave. Wind Speed	13	14	11	15	14	10	14	15	14	18	13	10
	Wind Speed - 24-hr. ave.	7	8	5	10	5	5	8	10	5	9	5	5
022	Value (μg/m³)	32.0	30.0	14.0	17.0	30.0	60	48.0	37.0	31.0	50.0	31.0	25.0
	Date	11/25	12/4	1/25	2/4	3/2	4/2	5/4	6/11	7/7	8/14	9/6	10/30
	(1) 24-hr. ave. Wind Direction	290	118	95	111	263	47	136	196	121	140	(2)	110
	Max. 1-hr ave. Wind Speed	12	12	10	14	12	13	9	13	9	10	(2)	10
	Wind Speed - 24-hr. ave.	6	9	5	8	5	5	6	7	8	7	(2)	6
024	Value (μg/m³)	24.0	15.0	60.0	19.0	42.0	116	35.0	77.0	31.0	72.0	52.0	37.0
	Date	11/27	12/12	1/25	2/29	3/2	4/2	5/3	6/10	7/16	8/15	9/6	10/17
	(1) 24-hr. ave. Wind Direction	150	150	56	166	236	304	195	168	122	90	168	225
	Max. 1-hr. ave. Wind Speed	10	19	7	21	20	13	(2)	19	5	10	13	21
	Wind Speed - 24-hr. ave.	6	10	3	14	10	5	(2)	12	4	5	6	11

(1) Vector Averages
(2) Missing Data

Table B-34 COMPUTER OUTPUT - MULTIPLE
LINEAR REGRESSIONS FOR PARTICULATE CONCENTRATIONS

MULTIPLE REGRESSION. . . ., PARTIC 1
SELECTION 1

TERMINAL INPUT FORMAT : 36I2
INPUT RESIDUAL CODE, DEP VAR, NO IN INDEP VAR, ORDER OF INDEP VAR
0001080203040506070809

VARIABLE NO.	NAME	MEAN	STANDARD DEVIATION	CORRELATION X VS Y	REGRESSION COEFFICIENT	STD. ERROR OF REG. COEF.	COMPUTED T VALUE
2	WIND	6.94915	3.43120	0.43167	0.41173	1.14374	0.35999
3	RADI	365.00000	184.67297	0.33519	0.01125	0.01181	0.95263
4	OZON	54.38982	18.20474	0.36287	0.06166	0.13424	0.45929
5	RELH	52.18643	17.50804	-0.20116	-0.04606	0.10656	-0.43227
6	TEMP	42.94914	17.46461	0.41009	0.06845	0.16269	0.42077
7	PREC	0.02203	0.08004	0.28623	40.27844	20.03404	2.01050
8	SOIL	0.22068	0.04026	0.07106	-14.13440	48.42072	-0.29191
9	MXWS	17.81355	6.82407	0.50011	0.48622	0.60939	0.79788
DEPENDENT							
1	PART	12.06780	12.79526				

D
INTERCEPT -5.21753

MULTIPLE CORRELATION 0.61930

STD. ERROR OF ESTIMATE 10.82011

D ANALYSIS OF VARIANCE FOR THE REGRESSION

SOURCE OF VARIATION	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARES	F VALUE
ATTRIBUTABLE TO REGRESSION	8	3641.94629	455.24316	3.88848
DEVIATION FROM REGRESSION	50	5853.73437	117.07468	
TOTAL	58	9495.67969		

MULTIPLE REGRESSION . . . ., PARTIC 1
SELECTION . . . 2

TERMINAL INPUT FORMAT : 36I2
INPUT RESIDUAL CODE, DEP VAR, NO OF INDEP VAR, ORDER OF INDEP VAR
00010702030406070809

VARIABLE NO.	NAME	MEAN	STANDARD DEVIATION	CORRELATION X VS Y	REGRESSION COEFFICIENT	STD. ERROR OF REG. COEF.	COMPUTED T VALUE
2	WIND	6.94915	3.43120	0.43167	0.42877	1.13391	0.37814
3	RADI	365.00000	184.67297	0.33519	0.01233	0.01145	1.07691
4	OZON	54.38982	18.20474	0.36287	0.05938	0.13306	0.44628
6	TEMP	42.94914	17.46461	0.41009	0.08478	0.15698	0.54006
7	PREC	0.02203	0.08004	0.28623	37.24927	18.61827	2.00068
8	SOIL	0.22068	0.04026	0.07106	-16.63972	47.68777	-0.34893
9	MXWS	17.81355	6.82407	0.50011	0.49071	0.60442	0.81186
DEPENDENT							
1	PART	12.06780	12.79526				

D
INTERCEPT -8.17183

MULTIPLE CORRELATION 0.61744

STD. ERROR OF ESTIMATE 10.73350

D

ANALYSIS OF VARIANCE FOR THE REGRESSION

SOURCE OF VARIATION	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARES	F VALUE
ATTRIBUTABLE TO REGRESSION	7	3620.07495	517.15356	4.48887
DEVIATION FROM REGRESSION	51	5875.60547	115.20795	
TOTAL	58	9495.67969		

MULTIPLE REGRESSION . . . ., PARTIC 1
SELECTION 3

TERMINAL INPUT FORMAT : 36I2
INPUT RESIDUAL CODE,DEP VAR, NO OF INDEP VAR, ORDER OF INDEP VAR
00010702030405060709

VARIABLE NO. NAME	MEAN	STANDARD DEVIATION	CORRELATION X VS Y	REGRESSION COEFFICIENT	STD. ERROR OF REG. COEF.	COMPUTED T VALUE
2 WIND	6.94915	3.43120	0.43167	0.38624	1.13012	0.34177
3 RADI	365.00000	184.67297	0.33519	0.01013	0.01107	0.91522
4 OZON	54.38982	18.20474	0.36287	0.04262	0.11629	0.36654
5 RELH	52.18643	17.50804	-0.20116	-0.04978	0.10484	-0.47488
6 TEMP	42.94914	17.46461	0.41009	0.09602	0.13127	0.73149
7 PREC	0.02203	0.08004	0.28623	39.78131	19.78169	2.01102
9 MXWS	17.81355	6.82407	0.50011	0.48021	0.60355	0.79563
DEPENDENT						
1 PART	12.06780	12.79526				

D

INTERCEPT -7.58888

MULTIPLE CORRELATION 0.61845

STD. ERROR OF ESTIMATE 10.72263

D

ANALYSIS OF VARIANCE FOR THE REGRESSION

SOURCE OF VARIATION	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARES	F VALUE
ATTRIBUTABLE TO REGRESSION	7	3631.96851	518.85254	4.51275
DEVIATION FROM REGRESSION	51	5863.71484	114.97479	
TOTAL	58	9495.67969		

MULTIPLE REGRESSION . . . ., PARTIC 1
SELECTION 4

TERMINAL INPUT FORMAT : 36I2
INPUT RESIDUAL CODE, DEP VAR, NO OF INDEP VAR, ORDER OF INDEP VAR
00010603040506070809 9

VARIABLE NO. NAME	MEAN	STANDARD DEVIATION	CORRELATION X VS Y	REGRESSION COEFFICIENT	STD. ERROR OF REG. COEF.	COMPUTED T VALUE
3 RADI	365.00000	184.67297	0.33519	0.01022	0.01097	0.93111
4 OZON	54.38982	18.20474	0.36287	0.03298	0.11185	0.29483
5 RELH	52.18643	17.50804	-0.20116	-0.05070	0.10391	-0.48794
6 TEMP	42.94914	17.46461	0.41009	0.09368	0.12998	0.72078
7 PREC	0.02203	0.08004	0.28623	38.66760	19.34502	1.99884
9 MXWS	17.81355	6.82407	0.50011	0.67110	0.22674	2.95973
DEPEDENT						
1 PART	12.06780	12.79526				

D

INTERCEPT -7.63885

```
MULTIPLE CORRELATION          0.61731

STD. ERROR OF ESTIMATE        10.63117

                  ANALYSIS OF VARIANCE FOR THE REGRESSION
D   SOURCE OF VARIATION      DEGREES        SUM OF         MEAN           F VALUE
                             OF FREEDOM     SQUARES        SQUARES
ATTRIBUTABLE TO REGRESSION       6          3618.54565     603.09082      5.33605
DEVIATION FROM REGRESSION       52          5877.13672     113.02185
    TOTAL                       58          9495.67969

MULTIPLE REGRESSION . . . ., PARTIC 1
     SELECTION    . . . . 5

TERMINAL INPUT FORMAT : 36I2
INPUT RESIDUAL CODE, DEP VAR, NO OF INDEP VAR,       ORDER OF INDEP VAR
0001050305060709
VARIABLE        MEAN          STANDARD       CORRELATION    REGRESSION     STD. ERROR     COMPUTED
NO.    NAME                   DEVIATION        X VS Y       COEFFICIENT    OF REG. COEF.   T VALUE
3      RADI    365.00000      184.67297       0.33519        0.01137       0.01016         1.11818
5      RELH     52.18643       17.50804      -0.20116       -0.04696       0.10224        -0.45935
6      TEMP     42.94914       17.46461       0.41009        0.10901       0.11809         0.92313
7      PREC      0.02203        0.08004       0.28623       38.37010      19.15154         2.00350
9      MXWS     17.81355        6.82407       0.50011        0.68386       0.22065         3.09933
DEPENDENT
 1 PART         12.06780       12.79526

D
INTERCEPT                      -7.33958

MULTIPLE CORRELATION            0.61647

STD. ERROR OF ESTIMATE         10.53920

                  ANALYSIS OF VARIANCE FOR THE REGRESSION
D   SOURCE OF VARIATION     DEGREES         SUM OF         MEAN           F VALUE
                            OF FREEDOM      SQUARES        SQUARES
ATTRIBUTABLE TO REGRESSION       5          3608.72583     721.74512      6.49784
DEVIATION FROM REGRESSION       53          5886.95703     111.07465
      TOTAL                     58          9495.67969

MULTIPLE REGRESSION . . . ., PARTIC 1
     SELECTION      . . . 6

TERMINAL INPUT FORMAT: 36I2
INPUT RESIDUAL CODE, DEP VAR, NO OF INDEP VAR,         ORDER OF INDEP VAR
00010403060709
VARIABLE        MEAN          STANDARD       CORRELATION    REGRESSION     STD. ERROR     COMPUTED
 NO.   NAME                   DEVIATION       X VS Y        COEFFICIENT    OF REG. COEF.   T VALUE
3      RADI    365.00000      184.67297       0.33519        0.01208       0.00997         1.21106
6      TEMP     42.94914       17.46461       0.41009        0.12831       0.10956         1.17117
7      PREC      0.02203        0.08004       0.28623       35.11320      17.66028         1.98826
9      MXWS     17.81355        6.82407       0.50011        0.69154       0.21840         3.16638
DEPENDENT
 1 PART         12.06780       12.79526
D
INTERCEPT                     -10.94388

MULTIPLE CORRELATION            0.61447

STD. ERROR OF ESTIMATE         10.46192
```

```
D            ANALYSIS OF VARIANCE FOR THE REGRESSION
    SOURCE OF VARIATION       DEGREES      SUM OF       MEAN         F VALUE
                             OF FREEDOM    SQUARES      SQUARES
 ATTRIBUTABLE TO REGRESSION       4      3585.28931    896.32227     8.18921
 DEVIATION FROM REGRESSION       54      5910.39062    109.45168
       TOTAL                     58      9495.67969

 MULTIPLE REGRESSION . . . ., PARTIC 1
      SELECTION   . . . . 7

 TERMINAL INPUT FORMAT : 36I2
 INPUT RESIDUAL CODE, DEP VAR, NO OF INDEP VAR,       ORDER OF INDEP VAR
 000103030709
 VARIABLE        MEAN        STANDARD     CORRELATION    REGRESSION    STD. ERROR      COMPUTED
 NO. NAME                    DEVIATION      X VS Y       COEFFICIENT   OF REG. COEF.    T VALUE
 3   RADI     365.00000     184.67297     0.33519         0.01966       0.00761        2.58453
 7   PREC       0.02203       0.08004     0.28623        35.10066      17.71983        1.98087
 9   MXWS      17.81355       6.82407     0.50011         0.76403       0.21016        3.63555
 DEPENDENT
  1 PART       12.06780      12.79526

D
 INTERCEPT                   -9.49295

 MULTIPLE CORRELATION         0.60147
 STD. ERROR OF ESTIMATE      10.49720

 D                ANALYSIS OF VARIANCE FOR THE REGRESSION
    SOURCE OF VARIATION      DEGREES       SUM OF        MEAN        F VALUE
                            OF FREEDOM     SQUARES      SQUARES
 ATTRIBUTABLE TO REGRESSION      3       3435.16431   1145.05469    10.39153
 DEVIATION FROM REGRESSION      55       6060.51562    110.19119
       TOTAL                    58       9495.67969

 MULTIPLE REGRESSION . . . ., PARTIC 1
        SELECTION    . . .  8

 TERMINAL INPUT FORMAT : 36I2
 INPUT RESIDUAL CODE, DEP VAR, NO OF INDEP VAR,        ORDER OF INDEP VAR
 0001020309

 VARIABLE        MEAN        STANDARD     CORRELATION    REGRESSION    STD. ERROR      COMPUTED
 NO.  NAME                   DEVIATION      X VS Y       COEFFICIENT   OF REG. COEF.    T VALUE
 3    RADI    365.00000    184.67297      0.33519        0.01806       0.00776         2.32691
 9    MXWS     17.81355      6.82407      0.50011        0.85809       0.21000         4.08620
 DEPENDENT
  1 PART       12.06780     12.79526
D
 INTERCEPT                  -9.80842

 MULTIPLE CORRELATION        0.56234

 STD. ERROR OF ESTIMATE     10.76775

 D                ANALYSIS OF VARIANCE FOR THE REGRESSION
     SOURCE OF VARIATION    DEGREES        SUM OF        MEAN        F VALUE
                           OF FREEDOM      SQUARES      SQUARES
 ATTRIBUTABLE TO REGRESSION      2       3002.79272   1501.39624    12.94927
 DEVIATION FROM REGRESSION      56       6492.89062    115.94447
        TOTAL                   58       9495.67969
 MULTIPLE REGRESSION ...., PARTIC 1
       SELECTION ..... 9
```

TERMINAL INPUT FORMAT : 36I2
INPUT RESIDUAL CODE, DEP VAR, NO OF INDEP VAR, ORDER OF INDEP VAR
00010109

VARIABLE NO. NAME	MEAN	STANDARD DEVIATION	CORRELATION X VS Y	REGRESSION COEFFICIENT	STD. ERROR OF REG. COEF.	COMPUTED T. VALUE
9 MXWS	17.81355	6.82407	0.50011	0.93772	0.21506	4.36023
DEPENDENT						
1 PART	12.06780	12.79526				

D

INTERCEPT -4.63638

MULTIPLE CORRELATION 0.50011

STD. ERROR OF ESTIMATE 11.17694

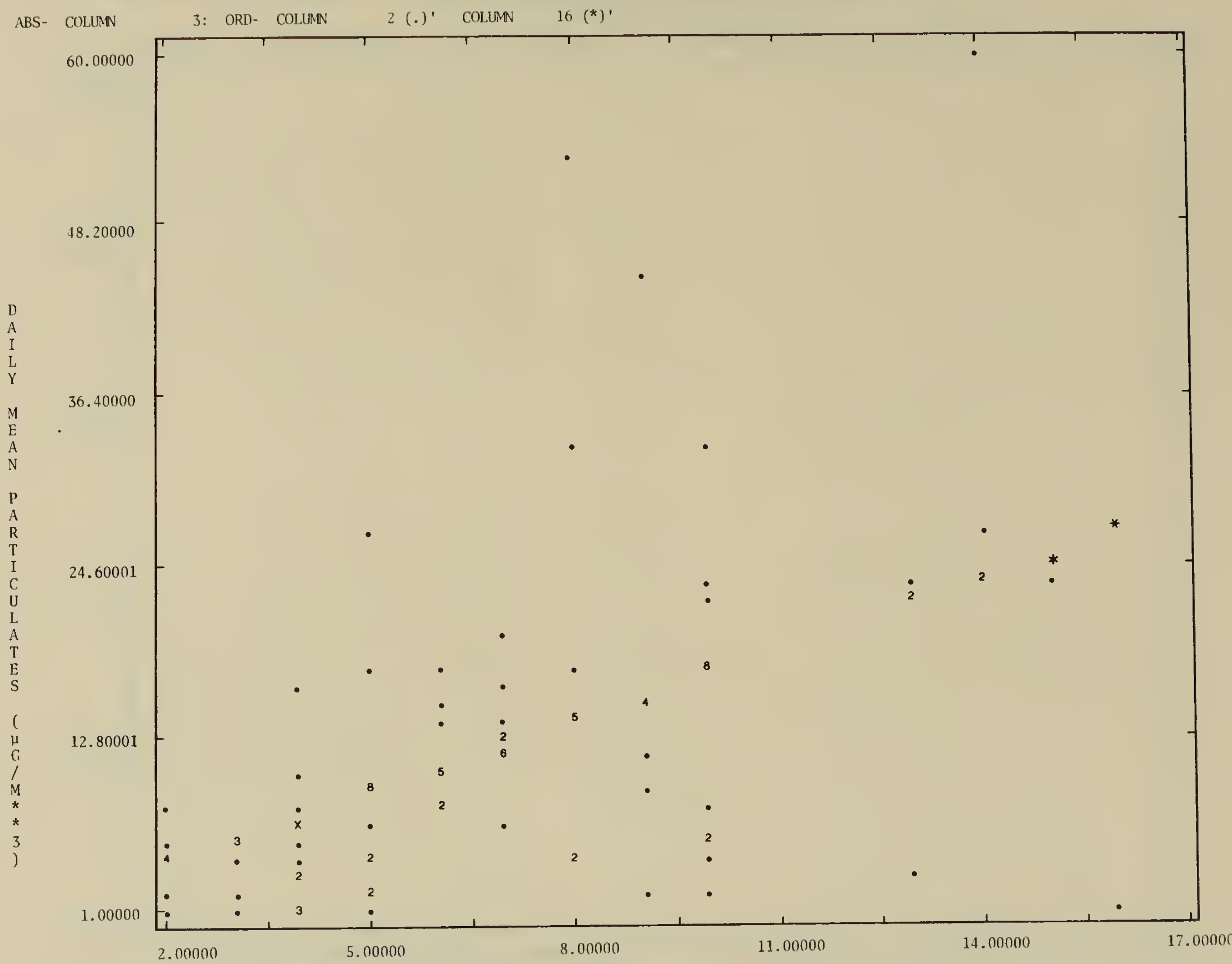
D

ANALYSIS OF VARIANCE FOR THE REGRESSION

SOURCE OF VARIATION	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARES	F VALUE
ATTRIBUTABLE TO REGRESSION	1	2375.01025	2375.01025	19.01163
DEVIATION FROM REGRESSION	57	7120.67187	124.92406	
TOTAL	58	9495.67969		

READY

OMNITAB LINEAR AND 2ND DEG REGRESS WITH PLOTS--PARTICULATES VS WIND SPEED



DAILY MEAN WIND SPEED (MPH)

TOTAL NO. OF PTS. PLOTTED IS 118 AND NO. NOT PLOTTED BECAUSE THEY FALL OUTSIDE OF BOUNDS IS 0

Figure B-32 CORRELATION OF DAILY MEAN PARTICULATES CONCENTRATION WITH DAILY MEAN WIND SPEED

OMNITAB LINEAR AND 2ND DEG REGRESS WITH PLOTS--PARTICULATES VS WIND SPEED

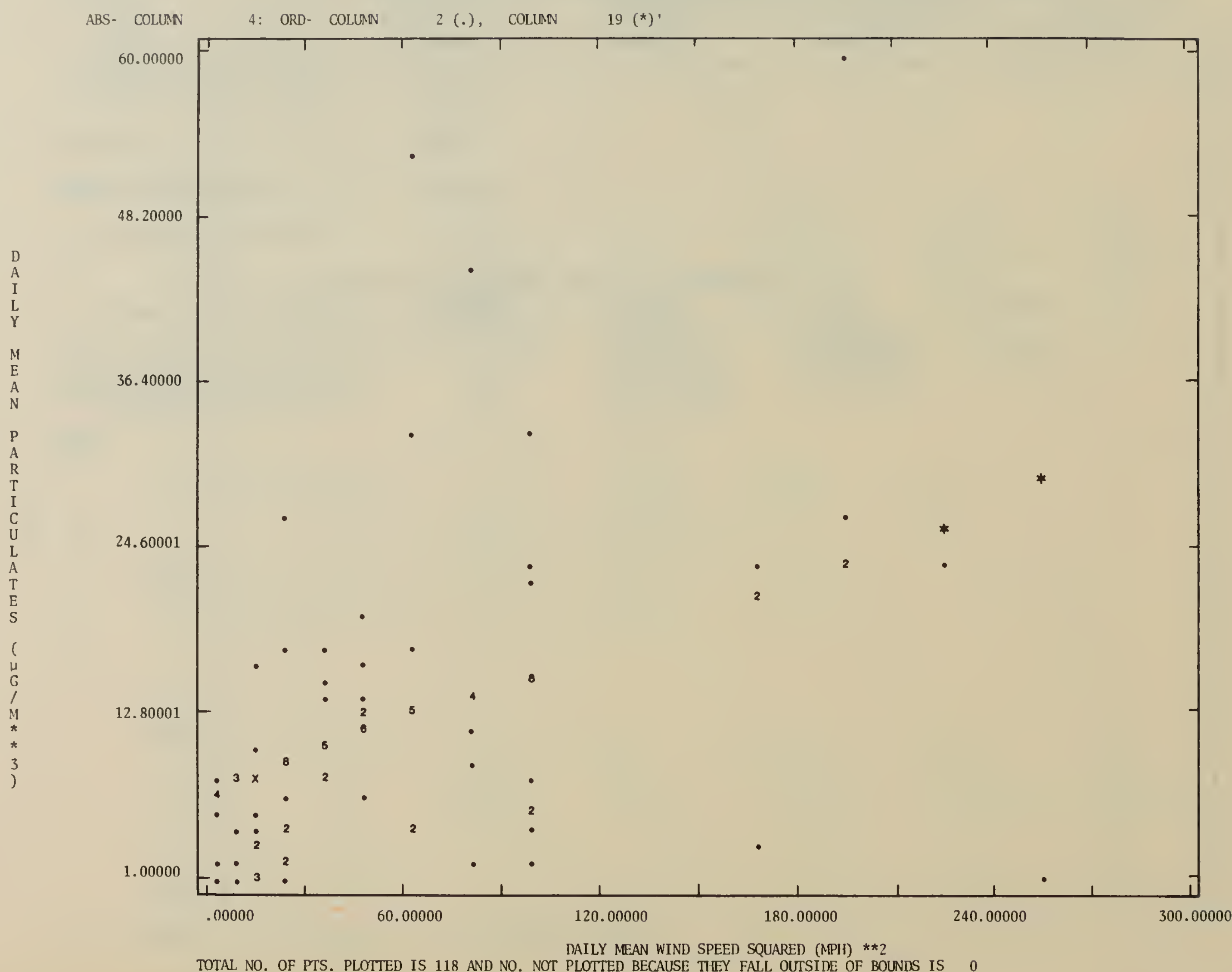
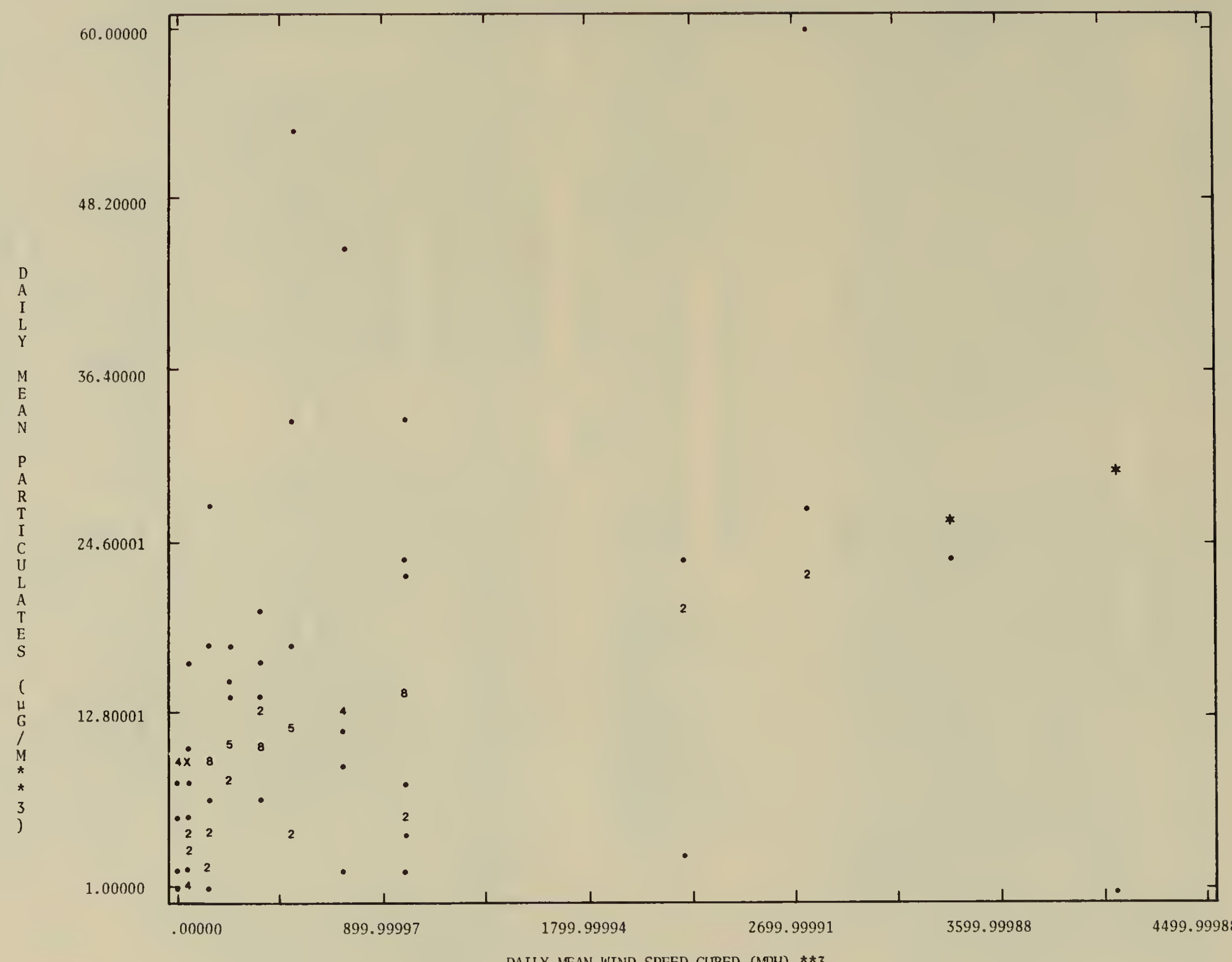


Figure B-33 CORRELATION OF DAILY MEAN PARTICULATES CONCENTRATION WITH DAILY MEAN WIND SPEED SQUARED

OMNITAB LINEAR AND 2ND DEG REGRESS WITH PLOTS--PARTICULATES VS WIND SPEED

ABS- COLUMN 5: ORD- COLUMN 2 (.)' COLUMN 22 (*)'

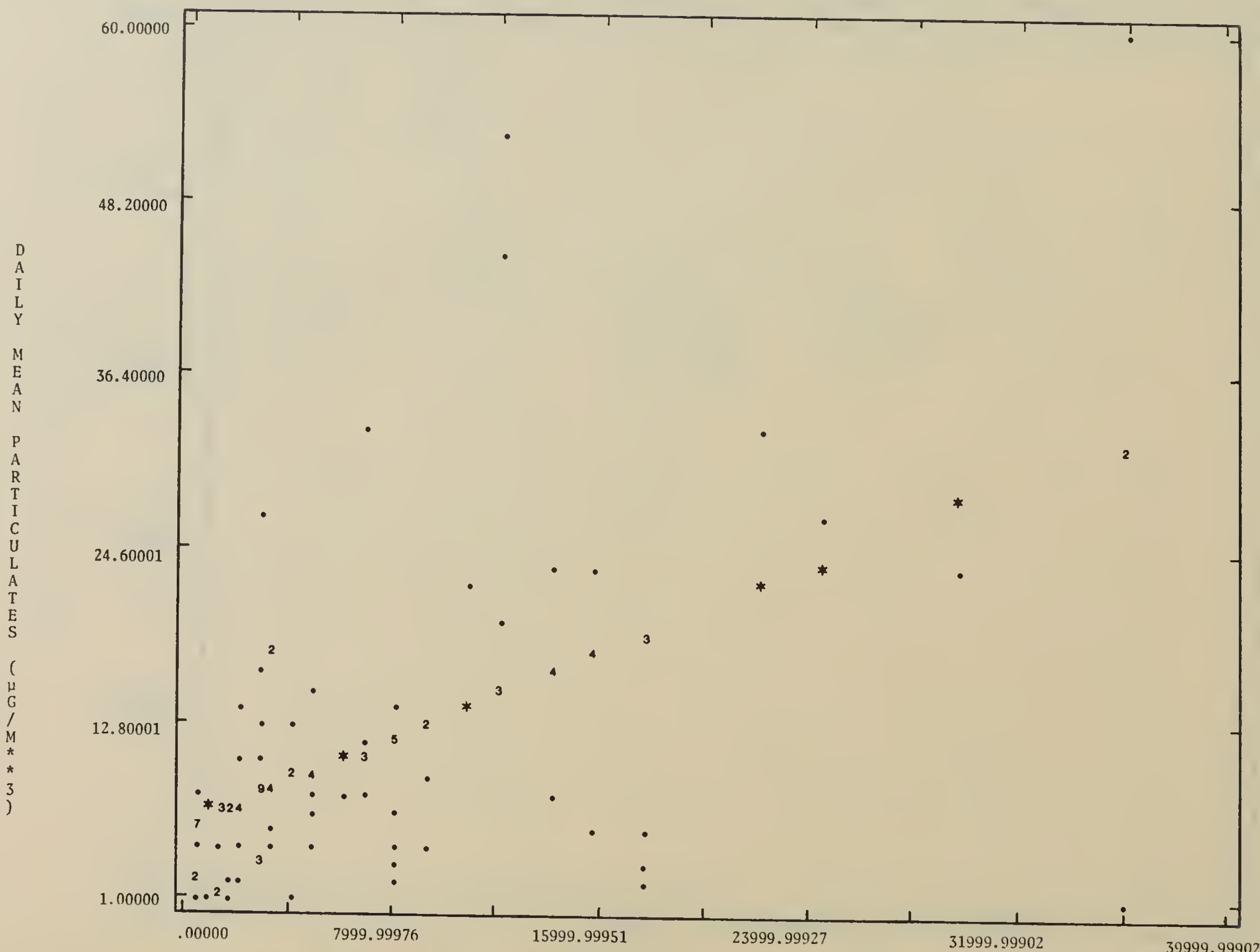


TOTAL NO. OF PTS. PLOTTED IS 118 AND NO. NOT PLOTTED BECAUSE THEY FALL OUTSIDE OF BOUNDS IS 0

Figure B-34 CORRELATION OF DAILY MEAN PARTICULATES CONCENTRATION WITH DAILY MEAN WIND SPEED CUBED

OMNITAB LINEAR AND 2ND DEG REGRESS WITH PLOTS--PARTICULATES VS MAX WIND

ABS- COLUMN 5: ORD- COLUMN 2 (.)' COLUMN 22 (*)'



TOTAL NO. OF PTS. PLOTTED IS 126 AND NO. NOT PLOTTED BECAUSE THEY FALL OUTSIDE OF BOUNDS IS 0

Figure B-35 CORRELATION OF DAILY MEAN PARTICULATES CONCENTRATION WITH DAILY MEAN MAXIMUM WIND SPEED CUBED

B.2.3 Visibility

Data contained herein are in support of Section 3.2.7. The reader should consult that section first inasmuch as the appendix is not intended to be continuous and self-explanatory.

B.2.3.1 Visibility Conditions Encountered

Examples of visibility conditions encountered in the Piceance Creek basin area are visually described in Figure B-36 by color and black and white (B&W) photographs which depict the visual range during four general conditions: restricted, low, medium, and high visibility. Photographs from View I are used to typically illustrate these various conditions. Each set of photographs in this figure were taken concurrently; the color photographs record the sky conditions and major restrictions to visibility; the B&W photographs provide data for analysis. The approximate area represented by the B&W photographs in the color photographs is outlined in black.

B.2.3.1.1 Restricted Conditions

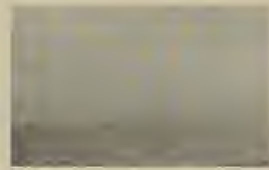
Under restricted conditions, the photographic objects are not visible. Under these circumstances, visual range calculations cannot be made, although a daily mean can be obtained if the objects become visible at a later hour.

The first color photograph in Figure B-36 was taken at 0830 MST, December 14, 1975 during a snowstorm which lasted until early afternoon. All views were obscured by the snow and remarks in the Site Log indicate the severity of the storm:

> "It's a real December snowstorm here. Roads (are) bad all the way from Rifle... Can't see anything over 1/2 mile away. Heater, in our shelter, will just barely keep it warm with it turned up as high as it will go. Snow comes inside all around bottom of door."

The snowstorm lasted until early afternoon, limiting visibility to less than an estimated one mile. No visual range measurements could be made during these conditions; however, by 1300 MST the storm had subsided and conditions began to improve. By 1400 MST the snow stopped and the sun appeared, allowing B&W photographs to be taken for the first time that day. During the last hour of photography, photographs were taken of all the views. The daily mean visual range for this day, based on two hours of data (1400 and 1500 MST), was 32 miles.

RESTRICTED



LOW

VISUAL RANGE = NO MEASUREMENT DAILY MEAN VR = 32 Miles

VISUAL RANGE = 45 Miles DAILY MEAN VR = 59 Miles

MEDIUM

HIGH

VISUAL RANGE = 71 Miles DAILY MEAN VR = 68 Miles

VISUAL RANGE = 109 Miles DAILY MEAN VR = 108 Miles

VISIBILITY CONDITIONS
ENCOUNTERED IN THE PICEANCE CREEK BASIN, COLORADO
SEPTEMBER, 1975 - SEPTEMBER, 1976

FIGURE B-36

Major areal restrictions to visibility such as the above, which obscured all objects for extended periods of time, were not common. Instances of isolated restrictions were more frequent. Scattered snowshowers during the winter and spring, and rainshowers during the summer and fall frequently obscured one or more of the objects in the views for short periods of time; during such instances, no visual range for inclusion into the statistical summary for that period.

B.2.3.1.2 Low Visibility

Minor restrictions to visibility, such as haze and smoke, which occasionally required the use of a nearer object to determine the visual range, were often observed. Reports of haze in the Site Log usually indicated that it occurred more frequently during the early morning hours in Views I and II, although the remaining views were not exempt from its presence. Haze never restricted visibility to the extent that no measurements could be made of a near object for data collection. Hourly comments recorded in the Site Log by the photographers provided additional information on the visibility conditions found during the photographic day. This information along with the individual hourly values will be available upon request.

The effect of haze on the contrast and clarity of the objects in the Piceance Creek basin area is illustrated in Figure B-36 by the second set of photographs. These photographs were taken September 27, 1975 at 0830 MST and represent a visual range of 45 miles. Remarks in the Site Log describe the day as sunny and clear, with calm winds and heavy haze in the western objects which obscured the second object in each of the two western views (Views I and II). As the day progressed, a light breeze began and by 1130 MST all the objects were visible. By 1400 MST, the wind was strong and gusty with very little haze remaining in the views; the daily mean visual range was 59 miles.

B.2.3.1.3 Medium Visibility

Daily mean visual ranges in the Piceance Creek basin area most frequently occurred between 60 and 70 miles during the year-long study. The third set of photographs in Figure B-36, taken July 30, 1976 at 0830 MST, represents visibility conditions present in the early morning of a day with a mean visual range of 68 miles; the visual range illustrated is 71 miles.

Remarks in the Site Log indicate that this day was characterized by early morning haze, increasing cloudiness in the afternoon and a few scattered showers at 1400 and 1500 MST. During the first hour of photography, the horizon was reported in the Site Log to

have a "brownish tint to it, more like smog than haze." This brownish tint is not readily apparent in the color photograph, although the clarity of the three ridges on the horizon is certainly less in this set of photographs than in the last set taken at the same time on a day of very high visibility. The change in contrast of the objects and horizon sky in the B&W photographs is also readily apparent.

B.2.3.1.4 High Visibility

The visual range shown in the last set of photographs in Figure B-36 is 109 miles and was recorded August 29, 1976 at 0830 MST. The day began clear and sunny with light haze reported in the views, although the skyline was reported in the Site Log to be "brownish" at 1030 and 1130 MST; the daily mean visual range was 108 miles.

The visual range illustrated in the last set of photographs does not represent the maximum value obtained during the study; however, it does illustrate the clarity and visibility conditions which can be expected to occur in the Piceance Creek basin area more frequently than does the maximum value. The maximum daily mean visual range recorded in the Piceance Creek basin was 130 miles on November 14, 1976. Daily mean visual ranges in excess of 100 miles and similar to that illustrated in the figure occurred approximately 16 percent of the time.

B.2.3.2 Visual Range Data

B.2.3.2.1 Daily Mean Visual Range

Daily mean visual range for each view is plotted on Figure B-37; the overall composite of the views is presented in Table B-35 along with the individual hourly minimum and hourly maximum for the day.

B.2.3.2.2 Monthly Mean Visual Range

Monthly composite distributions of visual range are presented in Figure B-38. Generally, those months with the highest monthly mean visual range also have the widest distribution of values.

B.2.3.2.3 Seasonal Mean Visual Range

The seasonal visual range summary by view is presented in Table B-36. Shown are the mean, the hourly maximum and minimum, fifth percentile, and standard deviation. Seasonal distributions

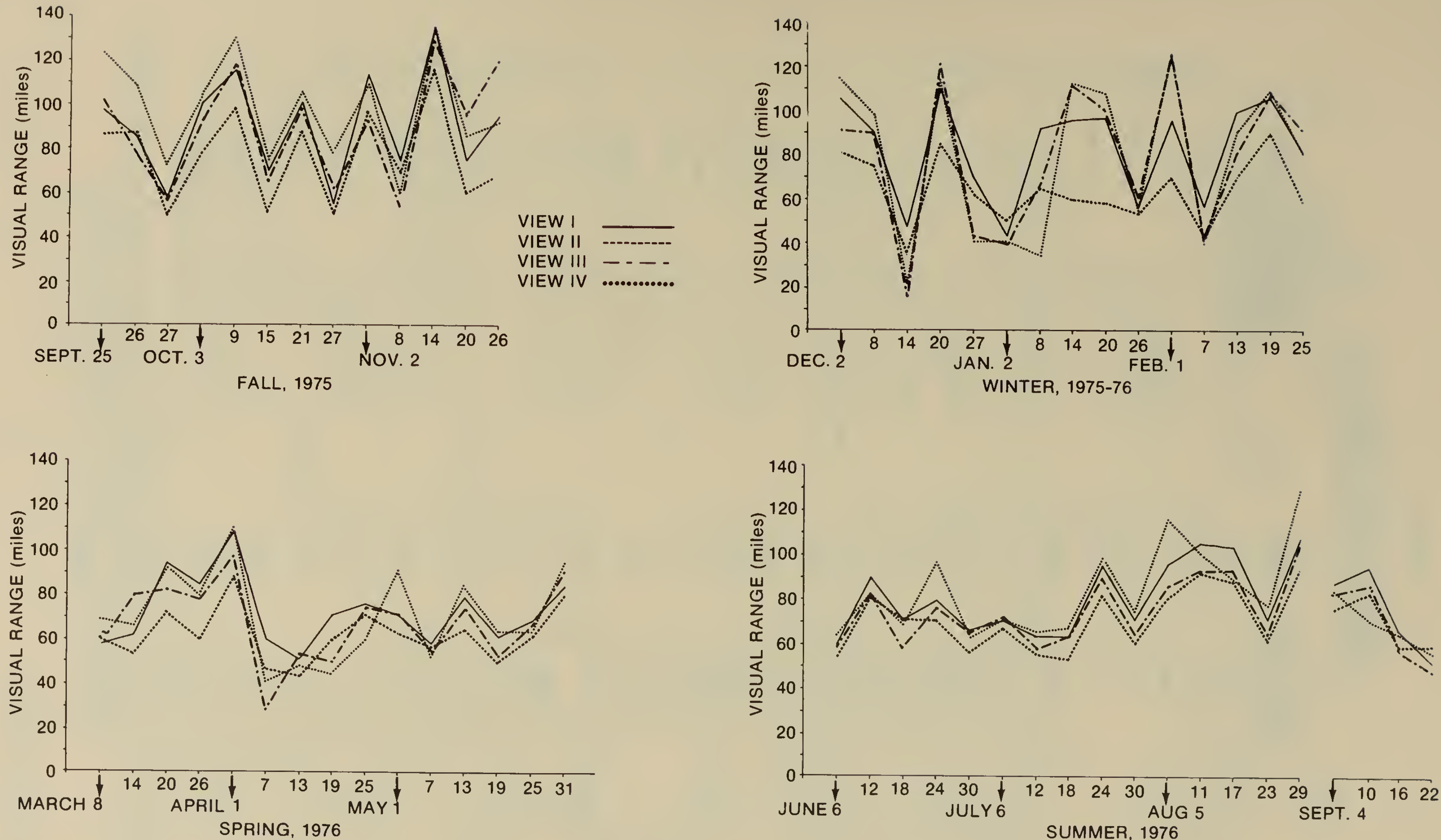


Figure B-37

VARIATION IN DAILY MEAN VISUAL RANGE FOR EACH VIEW
PICEANCE CREEK BASIN, COLORADO
SEPTEMBER, 1975 - SEPTEMBER, 1976

Table B-35

DAILY MEAN VISUAL RANGES
PICEANCE CREEK BASIN, COLORADO
SEPTEMBER 1975-SEPTEMBER 1976

DATE	MEAN VISUAL RANGE (miles)	HOURLY MIN/MAX	DATE	MEAN VISUAL RANGE (miles)	HOURLY MIN/MAX
September 25, 1975*	103	79/131	April 1	101	66/138
26*	87	69/119	7	45	18/72
27	59	42/77	13	48	16/58
October 3	93	68/114	19	56	14/109
9	116	84/144	25	72	45/106
15	66	44/93	May 1	75	57/124
21	99	78/117	7	56	30/82
27	63	42/98	13	76	57/101
November 2	106	82/130	19	58	27/75
8	66	24/92	25	65	33/89
14	130	106/140	31	88	61/112
20	80	44/144	June 6	59	45/74
26	95	44/128	12	84	61/101
December 2	98	69/145	18	68	50/113
8	88	45/139	24	81	64/117
14**	32	17/60	30	62	46/84
20	109	81/147	July 6	71	57/99
27	53	28/88	12	61	45/80
January 2, 1976	44	27/64	18	62	45/96
8	66	28/104	24	92	74/120
14	102	47/64	30	68	55/95
20	91	46/134	August 5	96	72/125
26	57	39/72	11	98	72/138
February 1	105	46/149	17	94	60/128
7	46	25/65	23	69	45/94
13	85	59/125	29	109	91/138
19	102	64/143	September 4	84	70/111
25	79	46/118	10	86	61/113
March 2	37**	27/55	16	64	46/84
8	61	45/89	22	54	35/88
14	65	38/93			
20	85	57/116			
26	75	46/102			

*Half-day practice sessions
**Based on two hours of data

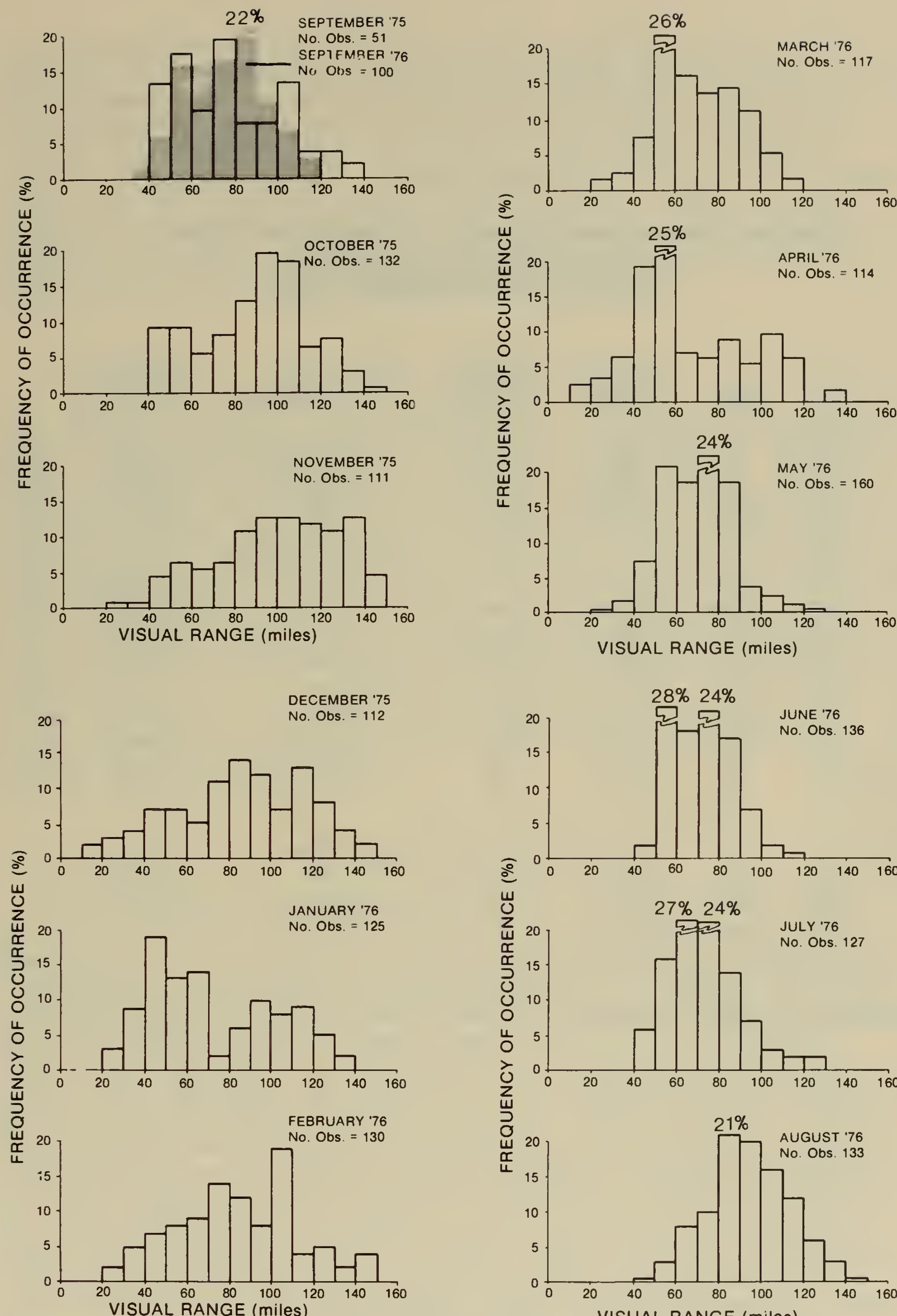


Figure B-38

MONTHLY COMPOSITE DISTRIBUTION OF VISUAL RANGE
PICEANCE CREEK BASIN, COLORADO
SEPTEMBER, 1975 - SEPTEMBER, 1976

Table B-36

SEASONAL VISUAL RANGE SUMMARY FOR EACH VIEW (MILES)
PICEANCE CREEK BASIN, COLORADO
SEPTEMBER 1975-SEPTEMBER 1976

	VIEW	MEAN	HOURLY MAXIMUM	HOURLY MINIMUM	5 PERCENTILE*	STANDARD DEVIATION
FALL	I	93	149	37	49	27.8
	II	77	142	42	43	23.6
	III	92	146	24	46	27.4
	IV	101	148	48	52	25.8
WINTER	I	87	143	31	41	23.9
	II	66	115	31	41	19.2
	III	83	149	17	30	34.1
	IV	86	147	22	26	35.4
SPRING	I	74	118	39	50	18.9
	II	63	113	32	40	16.5
	III	67	118	14	25	22.3
	IV	73	138	27	38	24.5
SUMMER	I	82	138	57	52	20.0
	II	72	128	45	46	16.6
	III	76	117	49	51	17.2
	IV	85	147	50	61	23.3

*5 percentile is that value above which occur 95 percent of the values

are presented on Figure B-39 in such a way that all views can be examined for one season or all seasons examined for one view. A tabular composite summed over all views is given on Table B-37. The seasonal variation in mean hourly visual range is plotted by view and the composite over all views on Figure B-40. Hourly mean visual ranges in Views III and IV exhibited a general decrease during the day, while the hourly means in Views I and II either fluctuated narrowly or increased. The largest variations in the hourly means generally occurred in Views III and IV, the most pronounced of which occurred during the spring.

B.2.3.2.4 Annual Mean Visual Range

Annual statistics are all contained in the main body of the report with the exception of the variation in mean hourly visual range, presented on Figure B-41. The mean hourly visual ranges shown on Figure B-41 reflect, as have other figures depicting annual statistics, general trends seen in each of the four monitoring seasons. As discussed in the seasonal analysis of visual range, the general trend in the mean hourly visual range in Views I and II was a net increase in the mean visual range during the day. In Views III and IV, the decline in the mean hourly visual range generally seen each season was readily apparent in the annual variation. The composite of the four views is also shown. On an "average" day, the mean hourly visual range decreases slightly until early afternoon, then increases to near the early morning level by midafternoon.

B.2.3.3 Visual Range Correlations

With reference to subsection 3.2.7.5.2, daily visual range has been correlated with eight primary variables (particulates, wind speed, solar radiation, ozone, relative humidity, temperature, precipitation, and maximum wind speed) and four secondary variables (mean wind speed squared, mean wind speed cubed, maximum wind speed squared, and maximum wind speed cubed). Basic data as input to this correlation and regression study are shown in the text on Table 3-34. They were first input to the multiple linear regression computer program. Table B-38 shows a typical output. In this output, visual range (Y) is the dependent variable in a multiple linear regression with eight other independent variables identified by column number and abbreviation. Means and standard deviations for each variable are calculated. The coefficient or correlation between the dependent variable (visual range) and each independent variable is the next output. Regression coefficients are the coefficients (b_i) in the equation for estimating visual range (Y est) given a set of observations for the eight independent variables (X_i).

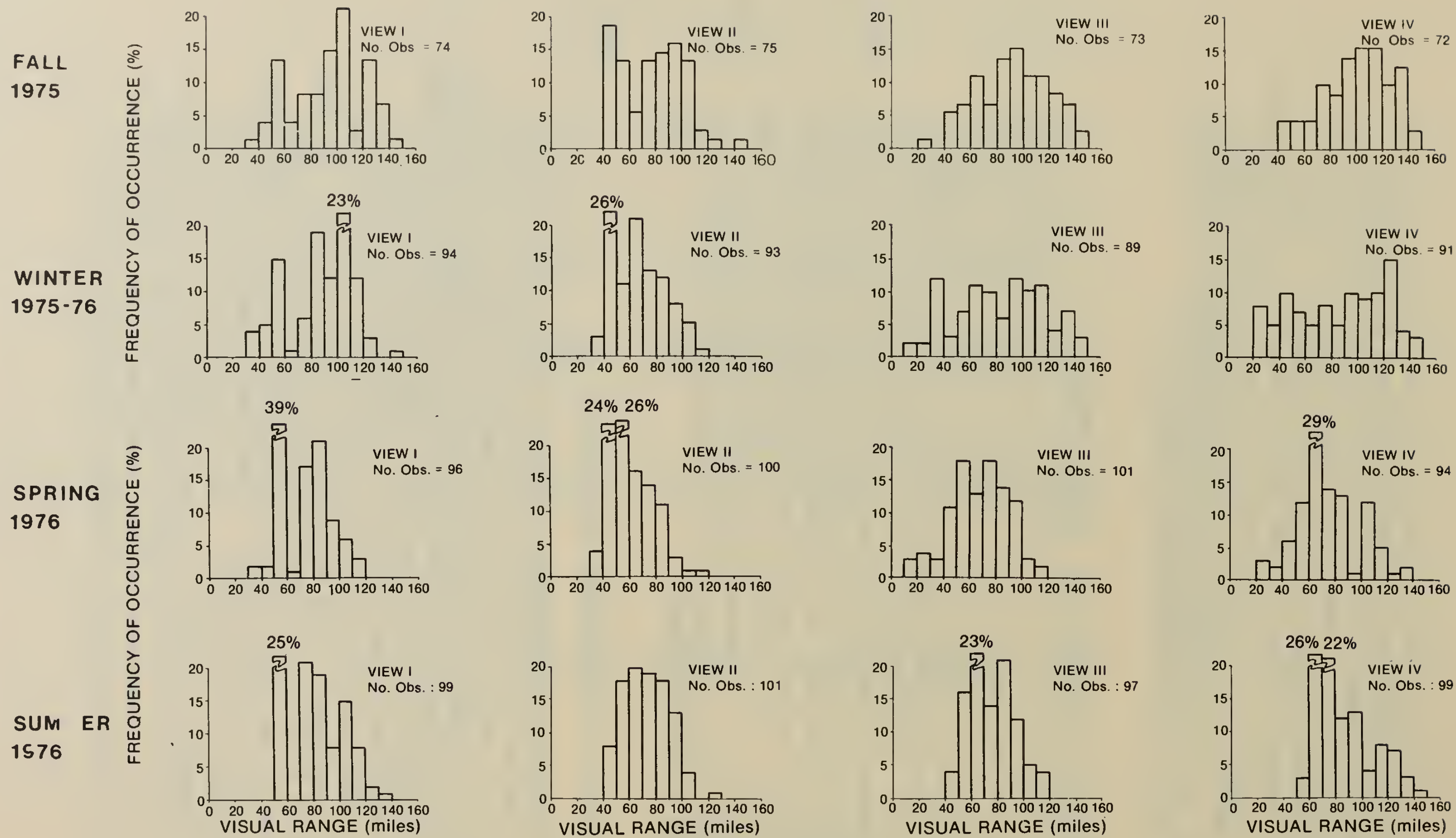


Figure B-39

SEASONAL DISTRIBUTION OF VISUAL RANGE IN EACH VIEW
PICEANCE CREEK BASIN, COLORADO
SEPTEMBER, 1975 - SEPTEMBER, 1976

Table B-37

SEASONAL COMPOSITE VISUAL RANGE SUMMARY
PICEANCE CREEK BASIN, COLORADO
SEPTEMBER 1975-SEPTEMBER 1976
(Miles)

SEASON	MEAN	HOURLY MAXIMUM	HOURLY MINIMUM	5 PERCENTILE*	STANDARD DEVIATION
Fall	91	149	24	45	27.3
Winter	80	149	17	33	30.0
Spring	69	138	14	39	21.1
Summer	79	147	45	51	20.0

*5 percent of the observations gave a visual range less than the indicated value

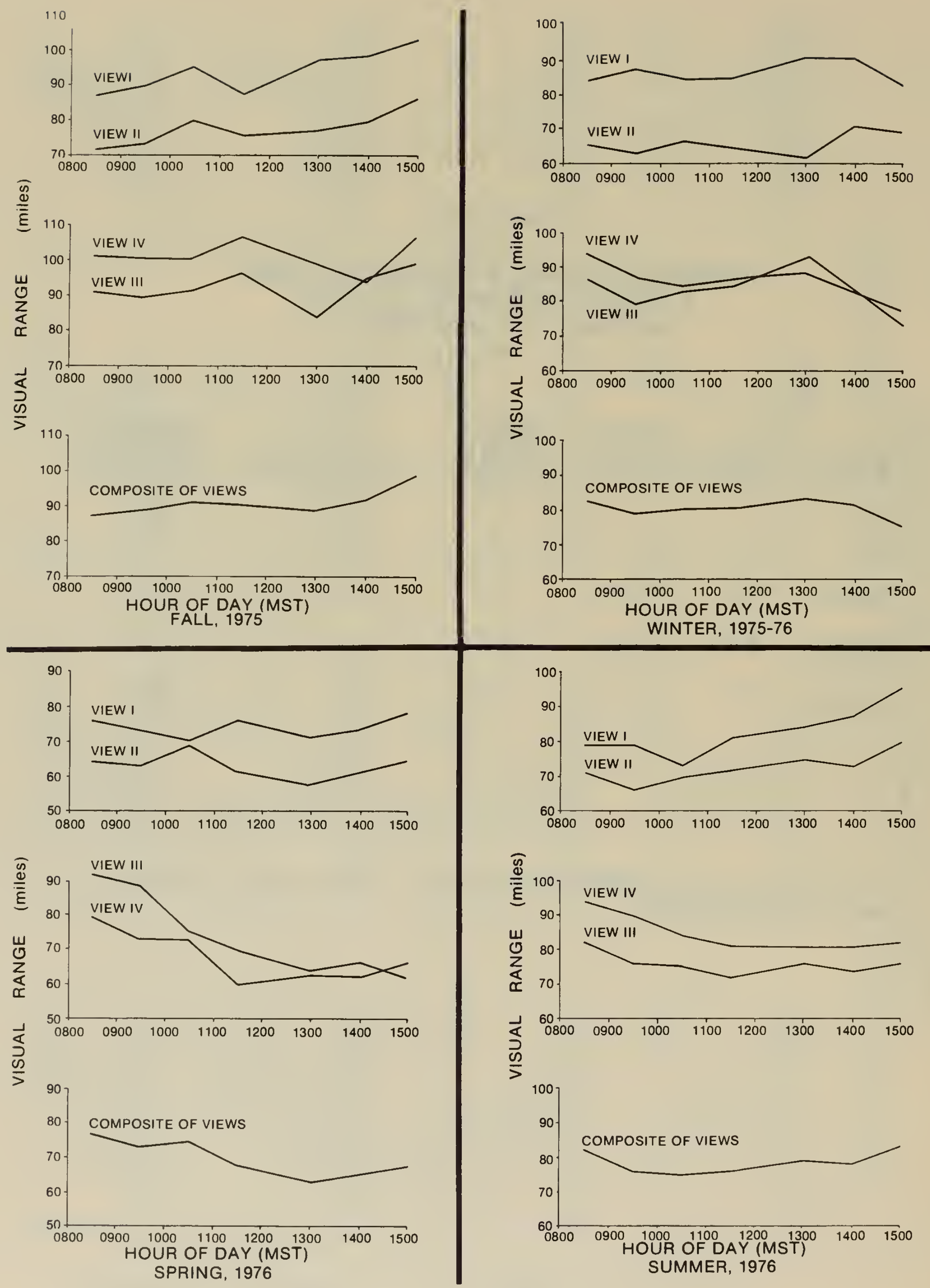


Figure B-40

SEASONAL VARIATION IN THE MEAN HOURLY VISUAL RANGE
PICEANCE CREEK BASIN, COLORADO
SEPTEMBER, 1975 - SEPTEMBER, 1976

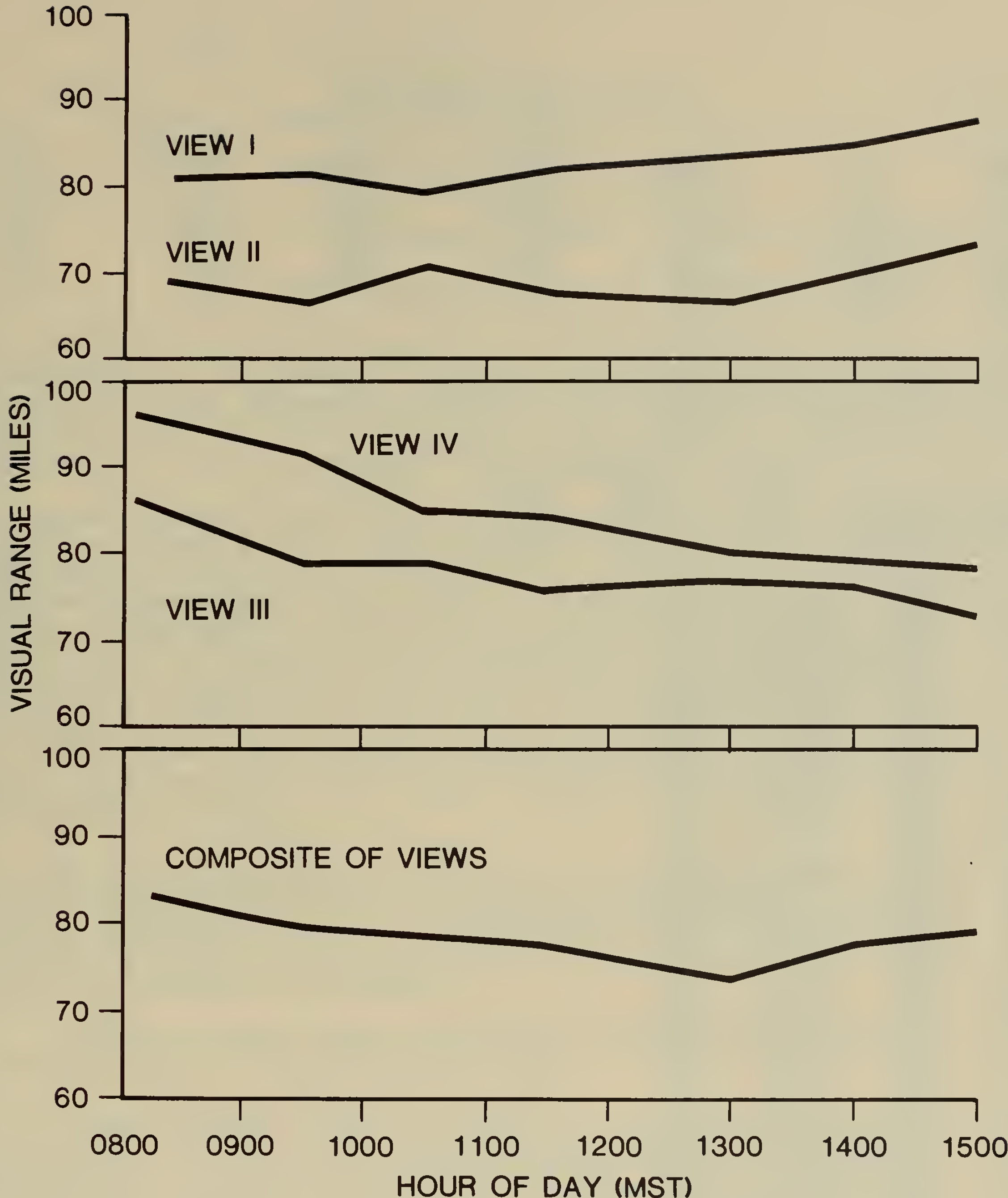


FIGURE B-41

VARIATION IN THE MEAN HOURLY VISUAL RANGE ON AN ANNUAL BASIS
PICEANCE CREEK BASIN, COLORADO SEPTEMBER, 1975-SEPTEMBER, 1976

Table B-38 VISUAL RANGE CORRELATION STUDY
OUTPUTS OF THE MULTIPLE LINEAR REGRESSION PROGRAM.

VARIABLE NO. NAME	MEAN	STANDARD DEVIATION	CORRELATION X VS Y	REGRESSION COEFFICIENT	STD. ERROR OF REG. COEF.	COMPUTED T VALUE
2 PART	11.69841	12.48818	-0.12527	-0.19653	0.21826	-0.90044
3 WS	6.92063	3.35193	-0.07194	2.78879	1.67267	1.66727
4 SOLR	363.79346	182.28917	0.11815	-0.00201	0.01728	-0.11638
5 OZ	54.39682	17.63472	-0.11070	-0.26147	0.18066	-1.44732
6 RH	52.65079	17.62888	-0.56049	-0.80853	0.15540	-5.20291
7 TEMP	43.96825	17.43645	0.11359	0.06991	0.18759	0.37267
8 PRCP	0.02063	0.07760	-0.30445	-6.42154	31.82642	-0.20177
9 MXWS	17.74602	6.64288	-0.17939	-1.79506	0.90046	-1.99349
DEPENDENT						
1 VR	76.11110	21.83521				

INTERCEPT 145.54860

MULTIPLE CORRELATION 0.69412

STD. ERROR OF ESTIMATE 16.84238

ANALYSIS OF VARIANCE FOR THE REGRESSION

SOURCE OF VARIATION	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARES	F VALUE
ATTRIBUTABLE TO REGRESSION	8	14242.1758	1780.27197	6.27595
DEVIATION FROM REGRESSION	54	15317.9492	383.67	
TOTAL	62	29560.1250		

TABLE OF RESIDUALS

CASE NO.	Y VALUE	Y ESTIMATE	RESIDUAL
1	103.00000	102.85052	0.14948
2	87.00000	91.29820	-4.29820
3	59.00000	92.41960	-33.41960
4	93.00000	104.54585	-11.54585
5	116.00000	102.35960	13.64040
6	66.00000	82.77805	-16.77805
7	99.00000	109.74802	-10.74802
8	63.00000	71.64949	- 8.64949
9	106.00000	85.11900	20.88100
10	66.00000	53.11830	12.88170
11	130.00000	105.57817	24.42183
12	80.00000	73.88162	6.11838
13	95.00000	71.01971	23.98029
14	98.00000	78.94160	19.05840
15	88.00000	87.07001	0.92999
16	32.00000	57.45181	-25.45181
17	109.00000	84.46030	24.53970
18	53.00000	70.93269	-17.93269
19	44.00000	63.15462	-19.15462
20	66.00000	80.85629	-14.85629
21	102.00000	84.47276	17.52724
22	91.00000	81.72942	9.27058
23	57.00000	68.22591	-11.22591
24	105.00000	98.25111	6.74889
25	46.00000	59.66068	-13.66068
26	85.00000	77.72916	7.27084
27	102.00000	75.97237	26.02763
28	79.00000	84.42595	-5.42595
29	37.00000	39.55606	-2.55606
30	61.00000	77.49277	-16.49277
31	65.00000	77.55208	-12.55208
32	85.00000	82.82391	2.17609
33	75.00000	76.80005	-1.80005
34	101.00000	93.45172	7.54828
35	45.00000	67.36577	-22.36577
36	78.00000	44.26459	33.73541
37	56.00000	51.42770	4.57230
38	72.00000	83.54727	-11.54727
39	75.00000	79.17375	-4.17375
40	56.00000	57.40829	-1.40829
41	76.00000	78.60242	-2.60242
42	58.00000	63.37761	-5.37761
43	65.00000	68.38339	-3.38339
44	88.00000	80.64290	7.35710
45	59.00000	77.54456	-18.54456
46	84.00000	74.92883	9.07117
47	68.00000	64.80724	3.19276
48	81.00000	71.68953	9.31047
49	62.00000	65.78316	-3.78316
50	71.00000	84.67441	-13.67441
51	61.00000	60.06512	0.93488
52	62.00000	48.61319	13.38681
53	92.00000	79.55478	12.44522
54	68.00000	55.61752	12.38248
55	96.00000	77.00494	18.99506
56	18.00000	67.44565	-49.44565
57	94.00000	85.58102	8.41898
58	69.00000	79.46239	-10.46239
59	109.00000	86.84746	22.15254
60	84.00000	90.15793	-6.15793
61	86.00000	74.77997	11.22003
62	64.00000	79.91249	-15.91249
63	54.00000	48.95392	5.04608

$$Y\ (est) = b_o + \sum_{i=1}^{n} (b_i X_i)$$

where b_o = intercept (also output)

n = number of independent variables

b_i = i th independent variable regression coefficient

X_i = observed value of the i th independent variable

The computed T value is the regression coefficient divided by its standard error. The computed T value is the relative measure of the contribution of an independent variable to the multiple regression equation. It is the basis for dropping out variables to obtain an equation with only the most significant predictors.

Other outputs in Table B-38 are the multiple correlation coefficient and standard error of the estimate. The higher the multiple correlation coefficient (1.0 is perfect), the better the regression equation estimates the actual value of the dependent variable. The analysis of variance for the regression provides a partitioning of the total sum of squares to the contributing regressions and carries it to the F - value which can be used to test the significance of the multiple correlation. In this case, a significant F-ratio is any value greater than 2.58 (from statistical tables $F_{.975}(8, 54)$= 2.58), which means the visual range is significantly influenced by the dependent variables.

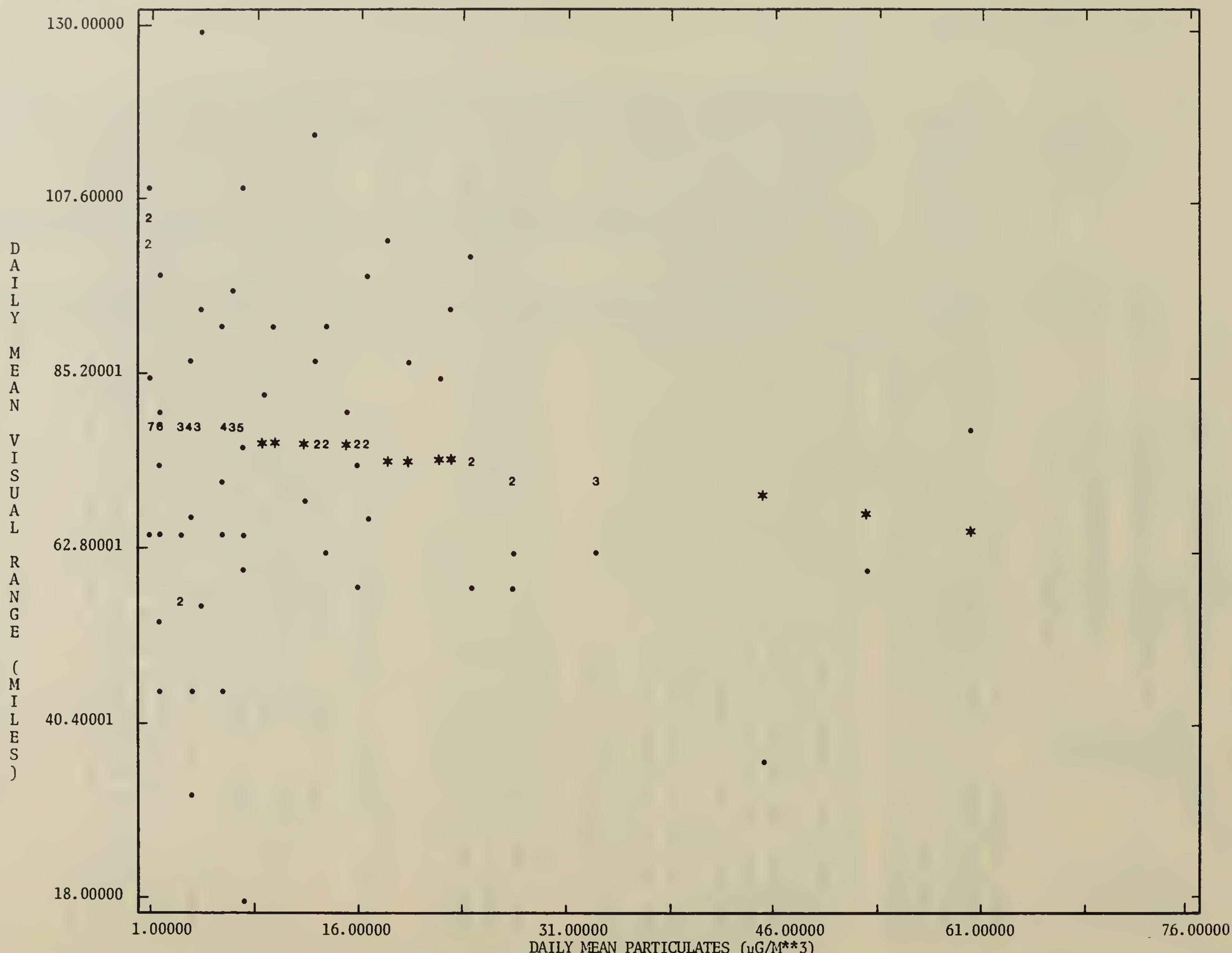
The table of residuals is an optional output that compares the observed visual range (Y) with the predicted visual range (Y est) using the regression equation. Residuals are the differences. The computed coefficients in the regression equation are the coefficients that minimize the residuals.

A summary of visual range correlations utilizing this program has been included in subsection 3.2.7.5.2.

A second computer program utilized was a polynomial fit with plotted output. First and second degree polynomials were computed and plotted. As stated in the text, the highest degree of correlation for visual range was obtained from relative humidity, presented as Figure 3-29. Other scatter diagrams of the paired observations showing the linear regression lines (as asterisked symbols) of each primary variable with visual range are presented in Figures B-42 through B-47. Figures B-48 and B-49 show mean wind speed squared and cubed in the same manner. Figure B-50 shows visual range as a function of the month of observation to examine seasonal trends in the data.

OMNITAB LINEAR AND 2ND DEG REGRESS WITH PLOTS--VISUAL RANGE VS ATMOSPHERE

ABS-COLUMN 2: ORD-COLUMN 1 (.). COLUMN 16 (*).

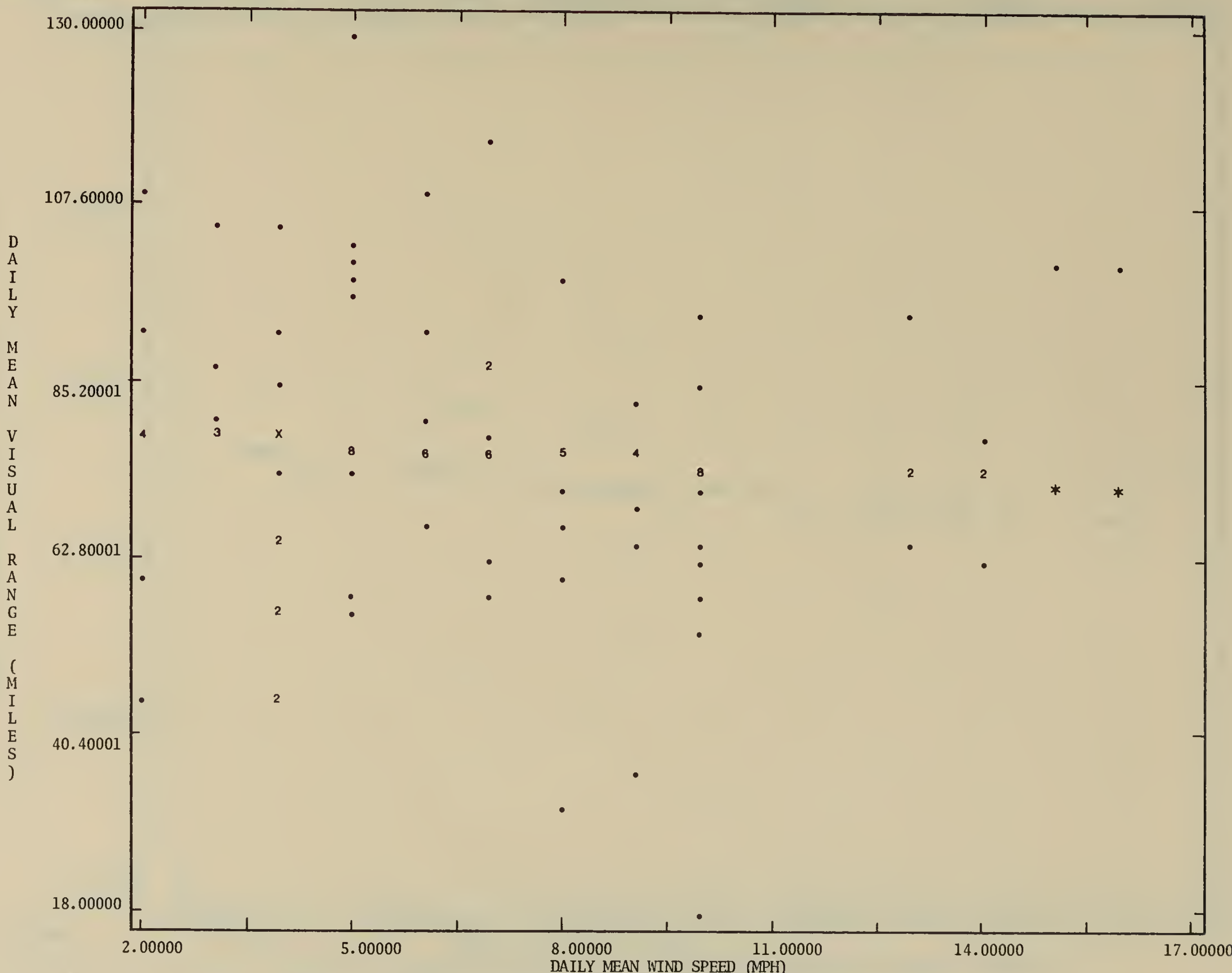


TOTAL NO. OF PTS. PLOTTED IS 118 AND NO. NOT PLOTTED BECAUSE THEY FALL OUTSIDE OF BOUNDS IS 0

Figure B-42 COMPUTER PLOT - VISUAL RANGE vs. DAILY MEAN PARTICULATES

OMNITAB LINEAR AND 2ND DEG REGRESS WITH PLOTS--VISUAL RANGE VS ATMOSPHERE

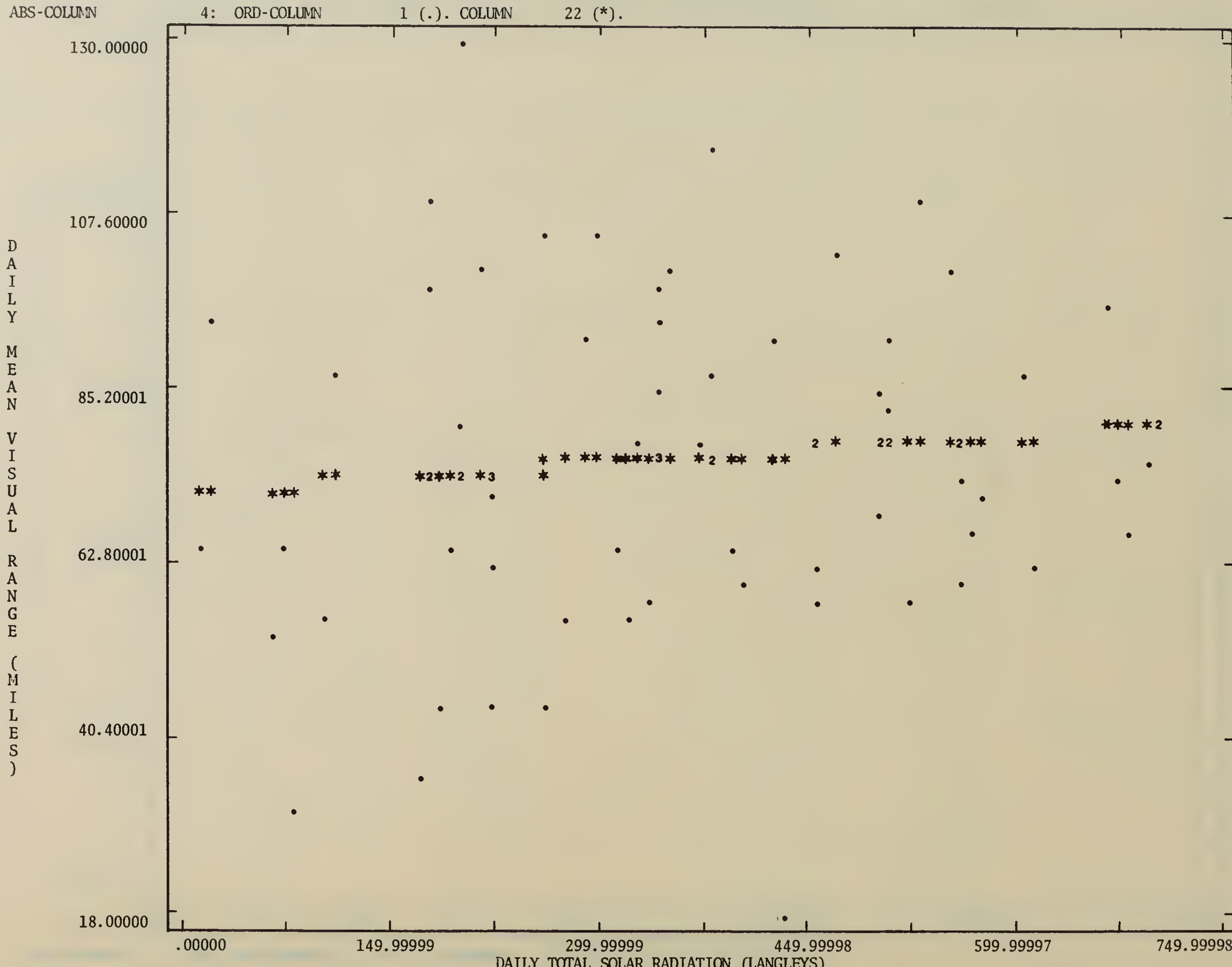
ABS-COLUMN 3: ORD-COLUMN 1 (.). COLUMN 19 (*).



TOTAL NO. OF PTS. PLOTTED IS 118 AND NO. NOT PLOTTED BECAUSE THEY FALL OUTSIDE OF BOUNDS IS 0

Figure B-43 COMPUTER PLOT-VISUAL RANGE vs. DAILY MEAN WIND SPEED

OMNITAB LINEAR AND 2ND DEG REGRESS WITH PLOTS--VISUAL RANGE VS ATMOSPHERE

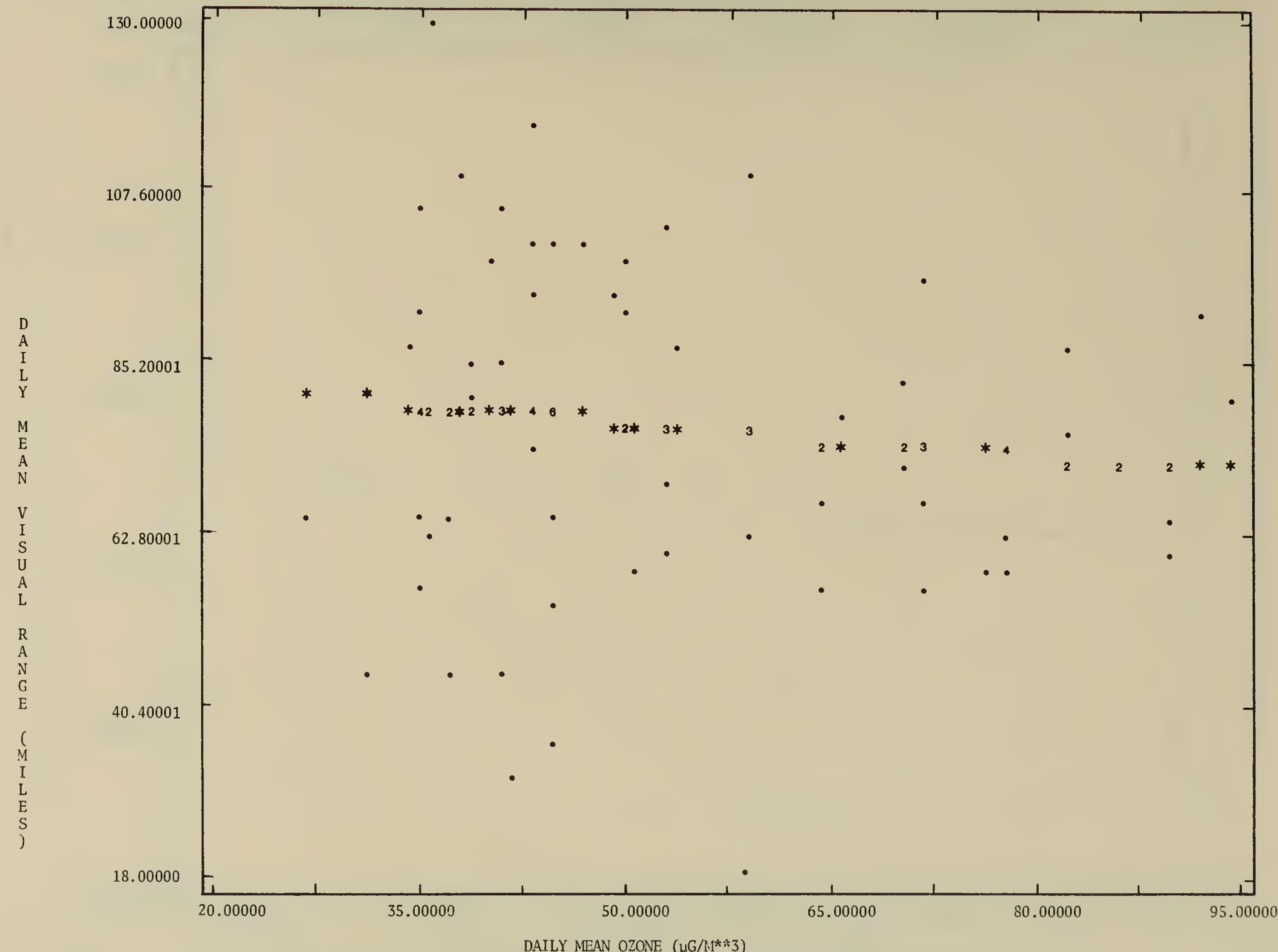


TOTAL NO. OF PTS. PLOTTED IS 118 AND NO. NOT PLOTTED BECAUSE THEY FALL OUTSIDE OF BOUNDS IS 0

Figure B-44 COMPUTER PLOT - VISUAL RANGE vs. DAILY TOTAL SOLAR RADIATION

OMNITAB LINEAR AND 2ND DEG REGRESS WITH PLOTS--VISUAL RANGE VS ATMOSPHERE

ABS- COLUMN 5: ORD- COLUMN 1 (.). COLUMN 25 (*).

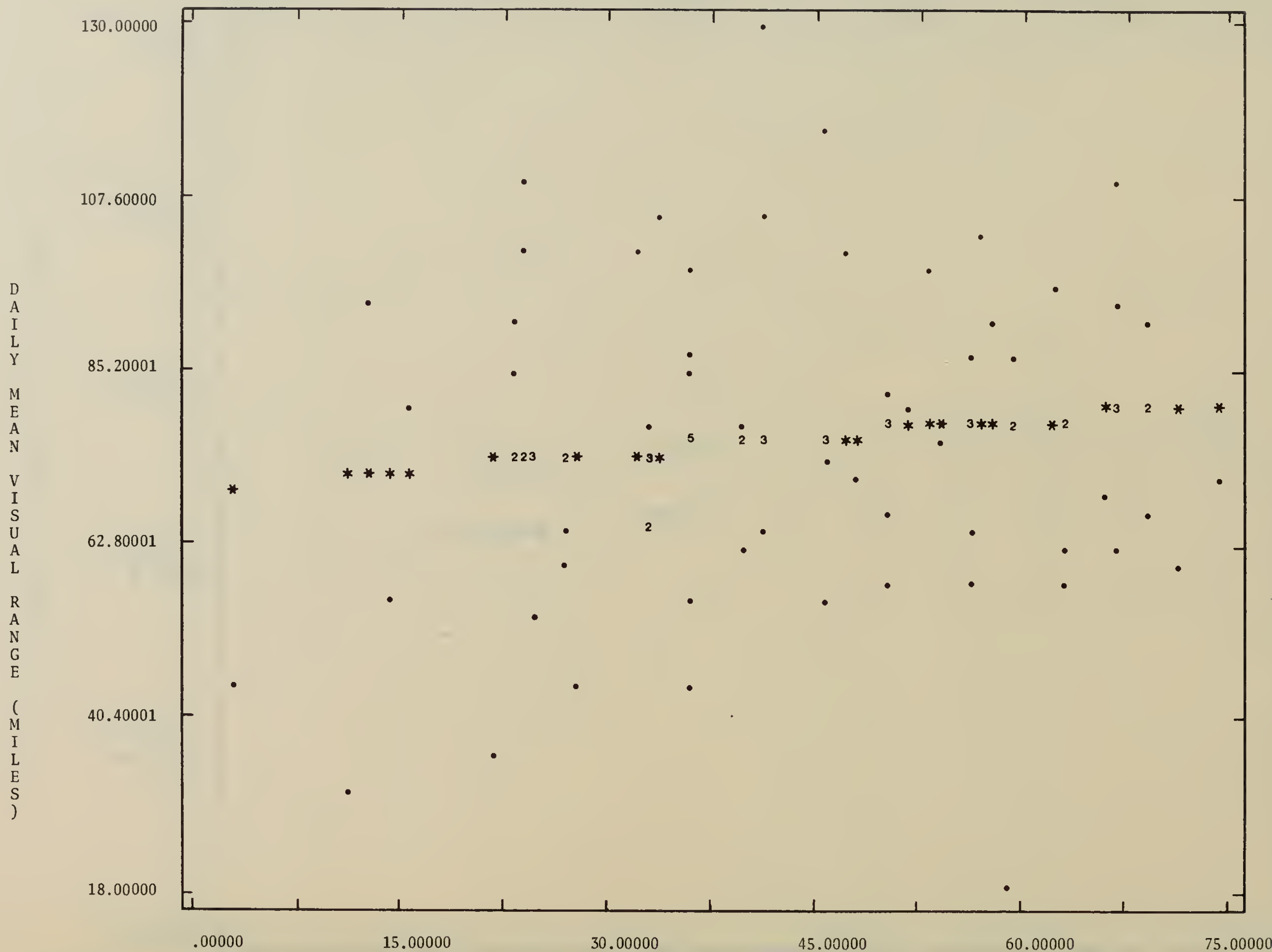


TOTAL NO. OF PTS. PLOTTED IS 118 AND NO. NOT PLOTTED BECAUSE THEY FALL OUTSIDE OF BOUNDS IS 0

Figure B-45 COMPUTER PLOT - VISUAL RANGE VS. DAILY MEAN OZONE

OMNITAB LINEAR AND 2ND DEG REGRESS WITH PLOTS--VISUAL RANGE VS ATMOSPHERE

ABS- COLUMN 7: ORD- COLUMN 1 (.). COLUMN 31 (*).

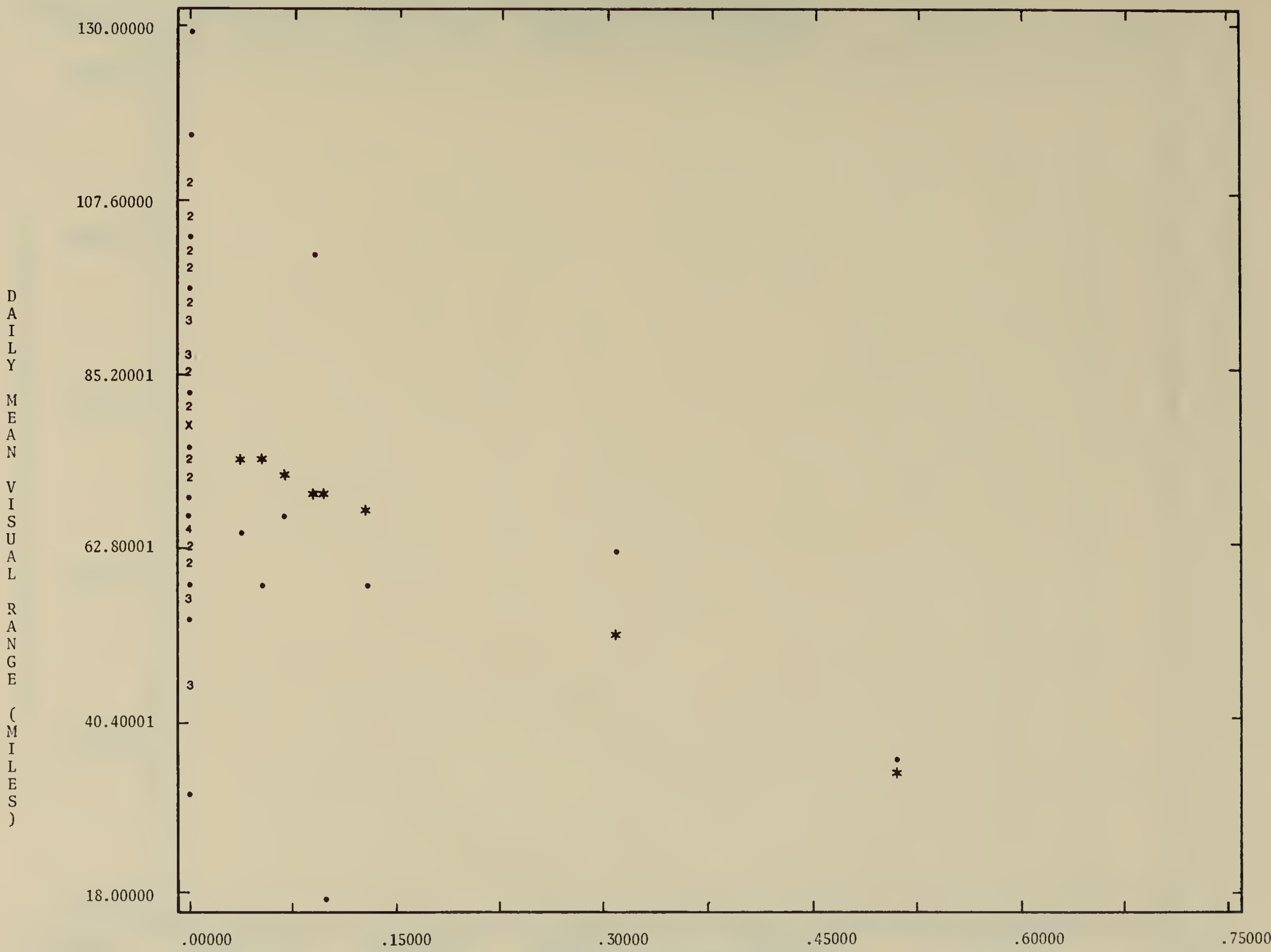


TOTAL NO. OF PTS. PLOTTED IS 118 AND NO. NOT PLOTTED BECAUSE THEY FALL OUTSIDE OF BOUNDS IS 0

Figure B-46 COMPUTER PLOT - VISUAL RANGE VS. DAILY MEAN TEMPERATURE

OMNITAB LINEAR AND 2ND DEG REGRESS WITH PLOTS--VISUAL RANGE VS ATMOSPHERE

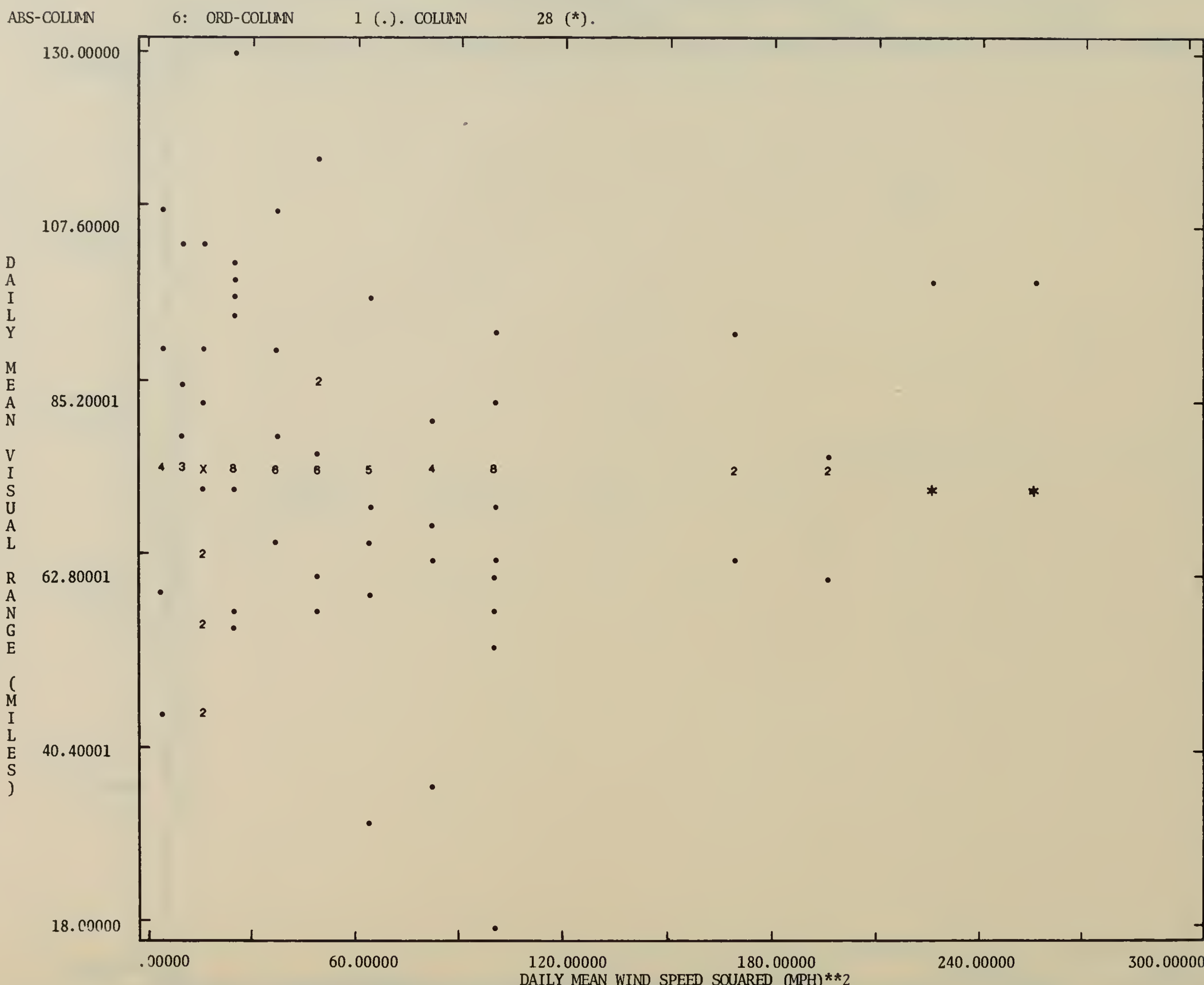
ABS- COLUMN 8: ORD- COLUMN 1 (.). COLUMN 34 (*).



TOTAL NO. OF PTS. PLOTTED IS 118 AND NO. NOT PLOTTED BECAUSE THEY FALL OUTSIDE OF BOUNDS IS 0

Figure B-47 COMPUTER PLOT - VISUAL RANGE VS. DAILY TOTAL PRECIPITATION

OMNITAB LINEAR AND 2ND DEG REGRESS WITH PLOTS--VISUAL RANGE VS ATMOSPHERE

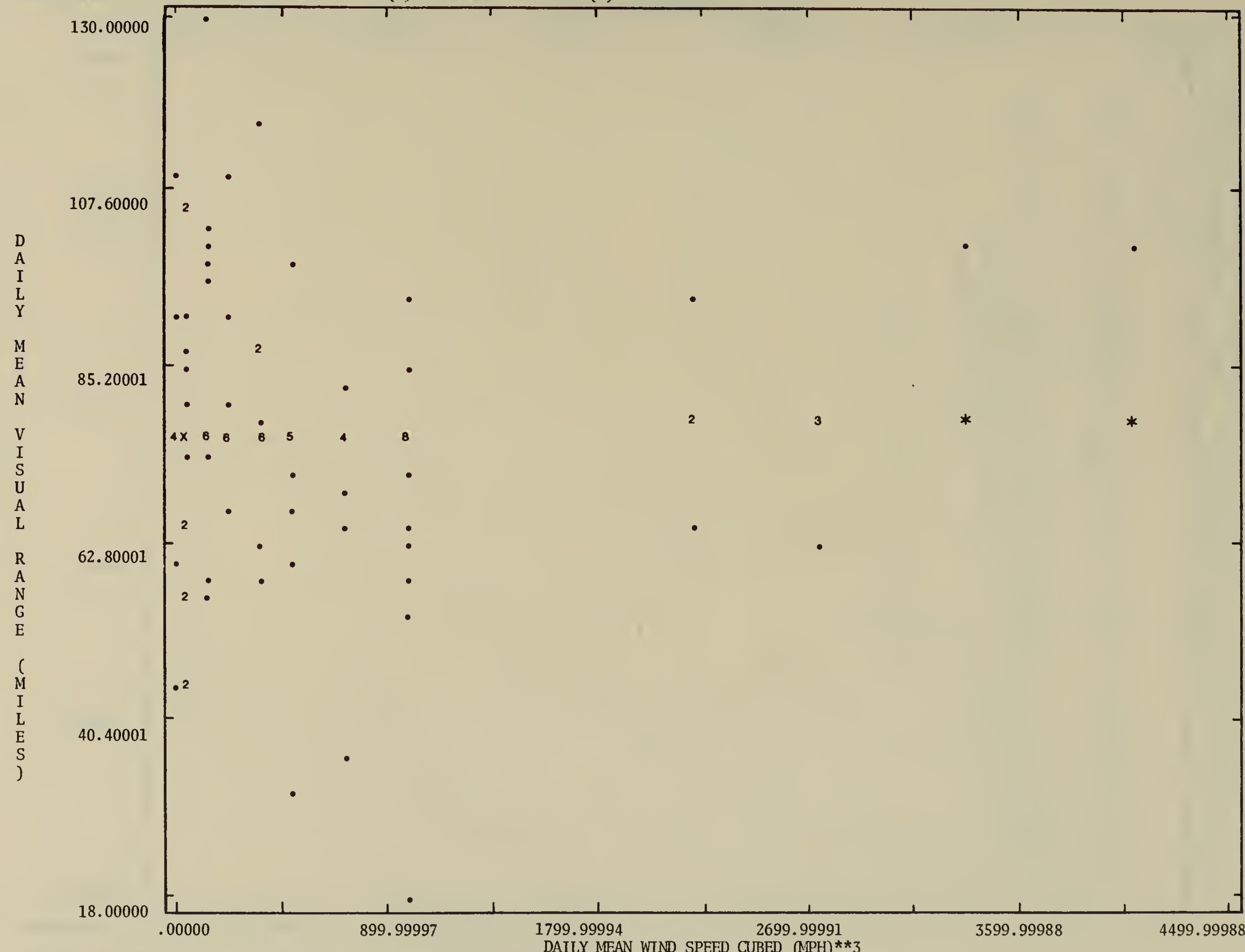


TOTAL NO. OF PTS. PLOTTED IS 118 AND NO. NOT PLOTTED BECAUSE THEY FALL OUTSIDE OF BOUNDS IS 0

Figure B-48 COMPUTER PLOT - VISUAL RANGE vs. DAILY MEAN (wind speed)^2

OMNITAB LINEAR AND 2ND DEG REGRESS WITH PLOTS--VISUAL RANGE VS ATMOSPHERE

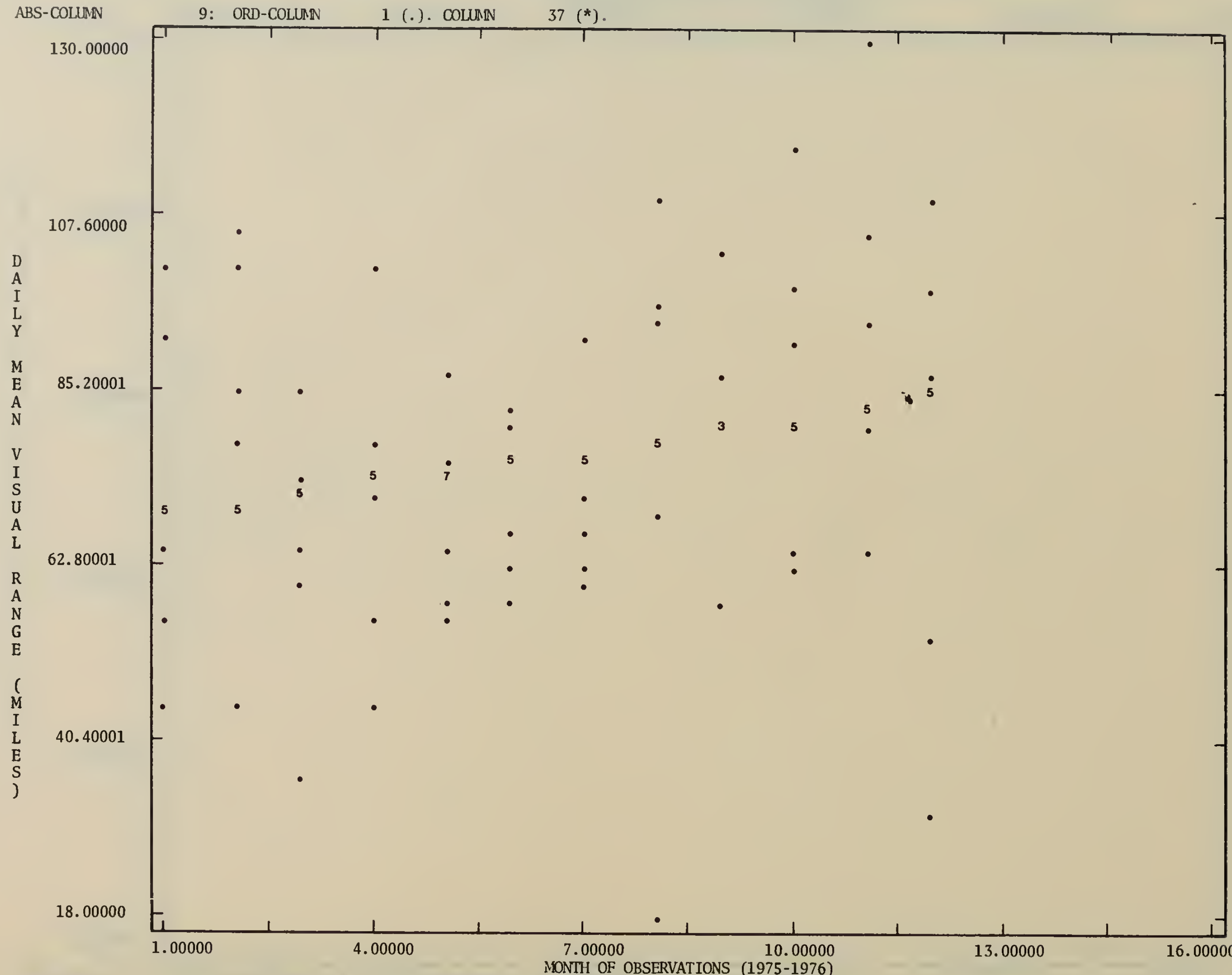
ABS-COLUMN 7: ORD-COLUMN 1 (.). COLUMN 31 (*).



TOTAL NO. OF PTS. PLOTTED IS 118 AND NO. NOT PLOTTED BECAUSE THEY FALL OUTSIDE OF BOUNDS IS 0

Figure B-49 COMPUTER PLOT - VISUAL RANGE vs. DAILY MEAN (wind speed)^3

OMNITAB LINEAR AND 2ND DEG REGRESS WITH PLOTS--VISUAL RANGE VS ATMOSPHERE



TOTAL NO. OF PTS. PLOTTED IS 118 AND NO. NOT PLOTTED BECAUSE THEY FALL OUTSIDE OF BOUNDS IS 0

Figure B-50 COMPUTER PLOT - VISUAL RANGE vs. MONTH OF OBSERVATION

B.2.4 EPA Position Papers

There have been two preliminary EPA policy statements relative to emission offset requirements that pertain to high background levels of particulates, ozone, and hydrocarbons sometimes found in rural areas. These policy statements support Section 3.2.4 of this report. They are:

Table B-39	1) Review of New Sources and Modifications. 40 CFS Part 51. December 21, 1976. Federal Register
Table B-40	2) Draft of a letter from Douglas M. Costle (EPA Administrator) to Chris Farrand (Acting Assistant Secretary of the Department of the Interior) dated March 30, 1977

tion under § 405.315a(e) or § 405.614(b) of this chapter.

* * * * *

[FR Doc.76-37382 Filed 12-20-76;8:45 am]

DEPARTMENT OF JUSTICE

Drug Enforcement Administration

[21 CFR Part 1309]

PAPAVER BRACTEATUM

Extension of Time for Comments and Hearing

On November 19, 1976, a notice of proposed production and control of Papever Bracteatum was published in the FEDERAL REGISTER (41 FR 51036). All interested parties were invited to comment or object to the proposal on or before December 21, 1976.

Pursuant to the authority under sections 301 and 501(b) of the Controlled Substances Act (21 U.S.C. 821 and 871 (b)) and by § 0.100 of Title 28, Code of Federal Regulations, to promulgate and enforce rules, regulations and procedures relating to drug abuse and drug trafficking, the Administrator of the Drug Enforcement Administration has decided to extend the time for submissions of comments to January 28, 1977. Further, public hearings will be held on January 27 and 28, 1977, for the purpose of hearing comments on the notice of proposed production and control of Papaver Bracteatum in the United States. The hearings will be held before Administrative Law Judge Francis L. Young in the DEA Hearing Room, 12th Floor, 1405 "I" Street NW., Washington, D.C., from 9:30 a.m. through 12:30 p.m. and 2:00 p.m. through 5:00 p.m. All persons desiring to furnish comments at the hearing shall provide written notice of intent to the Administrative Law Judge, Drug Enforcement Administration, United States Department of Justice, 1405 "I" Street NW., Washington, D.C. 20537, on or before January 14, 1977. All requests to present testimony shall include a brief summary as to the position to be taken and the approximate time needed to present the testimony.

The following procedures will be followed during the hearings. Speakers will be limited to 30 minutes. Written statements in addition to or in lieu of oral presentations will be accepted. There will be no relinquishing of time by one speaker to another. The hearings will not be adversary proceedings, and will be conducted in an informal but orderly manner in accordance with the directions of the Administrative Law Judge. The Administrative Law Judge, the Administrator and the Administrator's counsel may ask questions of speakers in order to clarify positions and to elicit particulars as are peculiarly within the pleader's knowledge.

Testimony at the hearing shall be reported verbatim. As soon as practicable after the hearings, the Administrative Law Judge shall prepare a report containing a synopsis of the testimony, his recommended findings of fact, and his recommended decision on the proposed production and control of Papaver Bracteatum in the United States.

All written comments on the notice of November 19, 1976, that are received prior to the public hearings shall be submitted for the record at the beginning of the hearings by the Administrative Law Judge. Testimony presented at the hearing shall relate to whether or not the production of Papaver Bracteatum in the United States is consistent with the public interest and with United States obligations under international treaties, conventions and protocols. If during the hearing, a dispute should develop as to the legal authority of the Administrator to issue a final order to accomplish a development of Papaver Bracteatum production in the United States, the Administrative Law Judge shall not hear such arguments, but shall direct that the matter be set for a separate hearing under the regular hearings procedures in Subpart D of Part 1316, Title 21, Code of Federal Regulations.

Dated: December 16, 1976.

PETER B. BENSINGER,
Administrator.

[FR Doc. 76-37494 Filed 12-20-76; 8:45 am]

VETERANS ADMINISTRATION

[38 CFR Part 1]

RELEASE OF INFORMATION FROM VA RECORDS OTHER THAN CLAIMANT RECORDS

Schedule of Fees

Notice is hereby given that the Veterans Administration is considering amending Part 1, Title 38 of the Code of Federal Regulations to change the schedule of fees indicated in § 1.555(h)(2), pertaining to charges for records search. The proposed amendment is issued to increase the search charge for the release of information from other than claimant records. This increase will reflect more correctly the cost to the Veterans Administration of performing document searches for release of information from other than claimant records.

Interested persons are invited to submit written comments, suggestions or objections regarding the proposal to the Administrator of Veterans Affairs (271A), Veterans Administration Central Office, 810 Vermont Avenue NW., Washington, D.C. 20420. All relevant material received before January 20, 1977, will be considered. All written comments received will be available for inspection at the above address only between the hours of 8 a.m. and 4:30 p.m. Monday through Friday (except holidays), during the mentioned 30-day period and for 10 days thereafter. Any person visiting Central Office for the purpose of inspecting any such comments will be received by the Central Office Veterans Services Unit in room 132. Such visitors to any Veterans Administration field station will be informed that the records are available for inspection only in Central Office and furnished the address and the above room number.

Notice is hereby given that it is proposed to make this regulation effective on the date of final approval.

The Veterans Administration has determined that this document does not contain a major proposal requiring preparation of an inflation impact statement under Executive Order 11821 and OMB Circular A-107.

Approved: December 15, 1976.

By direction of the Administrator.

A. J. SCHULTZ, Jr.,
Associate Deputy Administrator.

In § 1.555, paragraph (h)(2) is revised to read as follows:

§ 1.555 Fees.

* * * * *

(h) Schedule of fees: * * *

(2) Searching, per hour........ $4.45

(No charge for the first hour or fraction thereof.)

* * * * *

[FR Doc.76-37489 Filed 12-20-76;8:45 am]

ENVIRONMENTAL PROTECTION AGENCY

[40 CFR Part 51]

[FRL 660-6]

REVIEW OF NEW SOURCES AND MODIFICATIONS

Preparation, Adoption and Submittal of Implementation Plans; Requirements

The Environmental Protection Agency intends to amend 40 CFR Part 51 (Requirements for Preparation, Adoption and Submittal of Implementation Plans) to modify and clarify the requirements for preconstruction review of new or modified air pollution sources (40 CFR 51.18). The current version of 40 CFR 51.18 requires that each State Implementation Plan (SIP) under the Clean Air Act contain a regulation requiring preconstruction review and disapproval of all new or modified air pollution sources which would "interfere with" the attainment or maintenance of a national ambient air quality standard (NAAQS).

The tentative proposals outlined below are closely related to the Interpretative Ruling published elsewhere in today's FEDERAL REGISTER (at 41 FR 55524). The ruling provides in general that, under 40 CFR 51.18, a major new source may locate in an area violating a NAAQS only if stringent conditions can be met. These conditions are designed to insure that the new source's emissions will be controlled to the greatest degree possible; that more than equivalent offsetting emission reductions will be obtained from existing sources; and that there will be progress toward achievement of the NAAQS. (The conditions of the ruling are hereinafter collectively referred to as the "emission offset requirements.")

Interested persons are invited to participate in the development of the proposed rules by submitting written comments on the points raised in this notice (preferably in triplicate) to: Environmental Protection Agency, Control Programs Development Division (MD-15), Research Triangle Park, N.C. 27711. Persons commenting on this advance notice are also encouraged to comment on the basic policies and detailed provisions of the above-referenced Interpretative Ruling, and to prepare a single set of comments addressing both this notice and the ruling. All comments received on or before February 15, 1977, will be considered as EPA develops proposed modifications or clarifications. All comments submitted will be available for public inspection at EPA's Public Information Reference Unit, 401 M Street, S.W., Washington, D.C. 20460.

Definition of "Major" Source and Effect of Definition

EPA is contemplating a modification to 40 CFR 51.18 which would provide States with more explicit guidance on how they may focus their preconstruction review program resources on sources which have the greatest impact on air quality. The contemplated change would allow States to establish a two-level system for reviewing new sources. The complexity of the review would depend on the size of the proposed source.

States have always been allowed to exempt significant sources from review altogether, although firm national guidance has not been provided as to what constitutes an insignificant source. To remedy this, EPA proposed on July 8, 1975 (40 FR 28629) a list of such insignificant sources. Further action on this proposal has been deferred pending the more comprehensive amendments to § 51.18 outlined in this notice. Any additional comments on the July 8, 1975, proposals are solicited; comments previously submitted have been retained for consideration and need not be reimbursed.

Once the sources exempt from review altogether have been defined, the contemplated changes to § 51.18 would allow the remaining sources to be separated into two categories for review purposes. Those sources defined as "major" sources would be subject to an air quality analysis, and it found to exacerbate a violation of a NAAQS, would be subject to the emission offset requirements discussed above. In addition, only major sources would be subject to the public comment requirements set forth in 40 CFR 51.18.

Smaller sources would be reviewed to ensure compliance with applicable SIP emission limitations but would not be subject to the air quality analysis, public comment, and emission offset requirements. Another option would be to require the use of the lowest achievable emission rate (as defined in Part IV.A.1 of the ruling) for these smaller sources if they would be located in an area that exceeds a NAAQS.

Comments on the over-all approach outlined above are solicited, including an appropriate definition of "major" source. Of particular interest to the Agency are comments on the resource requirements related to any recommended definition of major source (i.e., number and kinds of sources subject to the emission offset requirements, man-hours required per review, etc.), and the percent of total new emissions which would be emitted by major sources under the recommended definition. To provide a basis for comment, the following tentative definition is offered:

"Major source" shall, as a minimum, cover any structure, building, facility, installation or operation (or combination thereof) for which the allowable emission rate is equal to or greater than the following:

	Tons per year
Particulate matter	50
Sulfur oxides	50
Nitrogen oxides	50
Non-methane hydrocarbons (organics)	50
Carbon monoxide	500

Similarly a "major modification" shall include a modification to any structure, building, facility, installation or operation (or combination thereof) which increases the allowable emission rate by the amounts set forth above. A proposed new source with an allowable emission rate exceeding the above amounts is considered a major source, even though such a source may replace an existing source with the result that the net additional emissions are increased by less than the above amounts.

Where a source is constructed or modified in increments which individually do not meet the above criteria, and which are not a part of a program of construction or modification in planned incremental phases previously approved by the reviewing authority, all such increments shall be added together for determining applicability under this definition. Moreover, where there is a group of proposed sources which individually do not meet the above criteria, but which would be constructed in substitution for a major source, the group should be collectively reviewed as a major source.

Allowable annual emissions shall be based on the applicable New Source Performance Standard (NSPS) set forth in 40 CFR Part 60 or the applicable SIP emission limitation, whichever is less, and the maximum annual rated capacity of the source. If the source is not subject to either a NSPS or SIP emission limitation, annual emissions shall be based on (1) the maximum annual rated capacity, and (2) the emission rate agreed to by the source as a permit condition.

The following shall not, by themselves, be considered modifications:

(1) Maintenance, repair, and replacement which the reviewing authority determines to be routine for a source category.

(2) An increase in the hours of operation, unless limited by previous permit conditions.

(3) Use of an alternative fuel or raw material, if the source is designed to accommodate such alternative use (unless limited by previous permit conditions).[1]

(4) Change in ownership of a stationary source.

Regardless of how "major source" is defined in a nationwide context, the applicability of the emission offset requirements may need to be extended to smaller sources in certain areas, depending on the magnitude of the air quality problem, growth rate and source mix, resources and technical expertise available to the reviewing authority, etc. Comments on whether more comprehensive reviews should be required in certain areas and the specific criteria for selecting these areas are also requested.

It should be noted that the above proposals relate only to reviews under 40 CFR 51.18; EPA is not in this notice suggesting the need for changes to its regulations for prevention of significant deterioration (40 CFR 52.21), new source performance standards (40 CFR part 60), or hazardous emission standards (40 CFR part 61). These regulations are already sufficiently precise as to their scope of coverage.

Geographic Applicability of Emission Offset Requirements for Hydrocarbon Sources

Because widespread violations of the NAAQS for photochemical oxidants have been found even in remote rural areas, some have assumed that hydrocarbon[2] control programs (including emission offset requirements) are necessary in all areas where there are violations of the photochemical oxidant NAAQS. Since photochemical oxidants or their precursors can be transported long distances, the focus for regulatory action must be on areas where the precursors and photochemical oxidants originate, not on areas where the photochemical oxidant levels are measured. In addition, it appears that in areas where there are considerably more hydrocarbons present than nitrogen oxides (high ratio of hydrocarbon-to-nitrogen oxides), changes in the levels of hydrocarbons present may result in relatively insignificant changes in the level of photochemical oxidants locally produced. Generally, such areas are found where the local emissions of nitrogen oxides are small, such as in rural areas.

The above findings, along with other studies, present convincing evidence that most of the rural photochemical oxidant problem results from the transport of both photochemical oxidant and its precursors from urbanized areas. Therefore, the photochemical oxidant reduction benefits to be gained from implementing the emission offset requirements for hydrocarbon sources locating in rural areas may be insignificant when compared to the benefits of focusing on the urbanized areas where most of the rural area problem originates.

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[1] Preliminary comment indicates that although this exemption is already codified in general EPA regulations regarding modifications (40 CFR 52.01(d)(2)(iii)), it should not apply in areas which are in violation of a NAAQS. The argument is that the exemption would allow major pollution increases in non-attainment areas to go unchecked. The Administrator agrees that this is a problem that should be reviewed and specifically invites comments on the issue.

[2] Hydrocarbons are precursors to photochemical oxidants.

In urban areas, the ratio of hydrocarbons-to-nitrogen oxides tend to be low so that changes in levels of photochemical oxidants locally generated are quite sensitive to changes in the levels of hydrocarbon present. Thus, hydrocarbon emission control programs (including the emission offset requirements) wold be expected to be effective in reducing the amount of photochemical oxidants locally generated in the urban area, thus also reducing the amount transported to neighboring rural areas.

An investigation is underway to determine the extent of the geographical area around urbanized locations where hydrocarbon emission control programs will be most effective in reducing photochemical oxidant levels. Early findings of this investigation indicate that these areas may be proportional to city size and may extend up to 85 miles from major metropolitan areas. In addition, upwind-downwind measurements around smaller urban areas and isolated point sources of hydrocarbons and nitrogen oxides indicate that there is little if any increase in observed photochemical oxidant concentrations as a result of the emissions from such smaller urban areas and isolated point sources. Although very limited data are available, it appears that urban areas with a population less than 200,000 produce little, if any, measurable increase in photochemical oxidant levels.

If these findings are confirmed, the policy evolving from such data might indicate that only major hydrocarbon sources locating within a specified distance of urban areas larger than 200,000 population would be subject to the emission offset requirements. Sources providing the offset would have to be located within the same specified area.

Comments on this and other possible criteria for determining the geographic applicability of the emission offset requirements for hydrocarbon sources are solicited. Comments are particularly desired on the need for obtaining emission offsets in remote rural areas that are, in most cases, exceeding the photochemical oxidant NAAQS and on the availability of emission offsets in such areas.

A preliminary draft of a report has been prepared which sets forth in more detail the basis for the tentative conclusions outlined above. This draft has been reviewed for its technical content by a limited number of scientific experts outside the Agency. Comments have been received and the report is being revised based on these comments. The revised report will be made available shortly for public inspection at EPA's Public Information Reference Unit, 401 M Street, S.W., Washington D.C. 20460. A notice of availability will be published in the FEDERAL REGISTER. Persons preparing comments on this notice may wish to refer to the report and comment on it.

"FUGITIVE DUST" ISSUES

There has been considerable concern about the location of major stationary sources of particulate matter in NAAQS non-attainment areas where fugitive dust has been determined to be the major cause of non-attainment. This concern has lead to several questions regarding the impact of fugitive dust sources (i.e., traffic on unpaved roads, construction, farming) upon existing air quality levels in both urban and rural areas.[3] This is due in part to the particle size distribution within fugitive dust areas. While data are relatively limited, they indicate that within fugitive dust areas a large portion of the total suspended particulate (TSP) collected upon the hi-volume air sampler is comprised of larger sized particles. In addition, there is a preponderance of larger sized particles associated with these fugitive dust sources. There is some question as to whether these larger sized particles by themselves cause any significant health or welfare related problems since both health and welfare criteria (especially visibility) are closely related to smaller sized particulate material.

The Agency currently believes that the fugitive dust problem within urban areas is more critical and should receive higher attention than similar type problems within rural areas. This lower priority of rural areas is based upon the belief that the toxic fraction of fugitive dust in areas without the impact of man-made pollutants is likely to be small. Fugitive dust sources in such areas include dust from deserts, arid lands, sparsely vegetated land, exposed but vacant lots in rural communities, dust from sparsely traveled unpaved roads and unpaved residential driveways, and other such conditions common in rural America. Fugitive dust in these areas is typically native soil that for various reasons becomes airborne. It is generally not exposed to potential contamination of industrial fallout or subject to adsorption of gaseous pollutants, which commonly occur in urban atmospheres. This analysis is supported by the belief that in rural areas relatively free from point emission sources, such as many areas of the Southwest, the TSP may be composed largely of non-toxic substances, such as silicates; although certain organic material, such as fungi and aeroallergenes, may be present in specific areas. No epidemiological studies have been conducted in sparsely populated areas where the TSP concentration may be high due to fugitive dust. In general, the population is too small to provide a statistically significant sample. Detailed information on the chemical composition of the TSP in these areas is not available; however, the toxic fraction is likely to be small.

Fugitive dust in urban areas, on the other hand, is a relatively different phenomenon. While mineral matter is still the primary ingredient, it can no longer be considered as native soil. In urban areas, it is contaminated to a measurable degree by various components highly suspect in health impairment. Urban fugitive dust contains fallout from industrial and combustion related processes, lead from automotive exhaust, measurable rubber tire particles, and other components associated with an advanced technologically-dependent community. Further contamination may result in urban areas from adsorption of harmful gases or adhesion of urban fine particulate matter on fugitive dust particles, making fugitive dust particles carriers of potentially more harmful and potent ingredients. In summary, while there is a need to be concerned with some aspects of the native dust problem itself within urban areas, the major concern is the potential for that native dust to be contaminated by more harmful substances than the dust itself, thereby causing the fugitive dust sources to contribute significantly to the level of harmful particulates found within urban areas.

The Agency is therefore considering a new source review policy which would recognize the differences between fugitive dust in urban and rural areas. Consequently, for new sources of particulate matter proposing to construct in rural areas that exceeding the TSP NAAQS, it is contemplated that they be allowed to construct without being subject to the emission offset requirements so long as they meet new source performance standards (NSPS) set forth in 40 CFR Part 60 or best available control technology, if no NSPS is applicable, and so long as their own emissions, plus consideration of "non-urban background"[4] and emissions from other stationary sources in the vicinity of the proposed location, do not cause violations of the NAAQS.

For new source review in NAAQS non-attainment urban areas, the emission offset requirements would be applicable. Since fugitive dust is recognized as a legitimate air pollution problem in urban areas, it would seem appropriate to allow emission offset credit to come from existing fugitive emission sources.

Comments on all aspects of the tentative approach outlined above are solicited. Comments are specifically solicited on the definition of "urban" and "rural" areas, on the issue of how large new sources of fugitive dust (i.e., strip mines, tailings operations) are to be considered when locating in rural areas, and whether (and to what extent) emission offsets of conventional stack emissions against fugitive dust-type sources should be permitted.

This advance notice of proposed rulemaking is issued under the authority of sections 110 and 301 of the Clean Air Act, as amended (42 U.S.C. 1857c-5 and g).

Dated: December 15, 1976.

RUSSELL E. TRAIN,
Administrator.

[FR Doc.76-37345 Filed 12-20-76;8:45 am]

[3] The term "fugitive dust" should be distinguished from the term—"fugitive emissions." The latter term generally refers to industrial process emissions which do not pass through a stack or chimney.

[4] Usually based upon the lowest measured annual average TSP air quality concentration in the broad area where the new source will be located, approximately 30 ug/m³.

Table B-40

Draft of a letter from Douglas M. Costle (EPA Administrator) to Chris Farrand (Acting Assistant Secretary of the Department of the Interior) dated March 30, 1977.

(letter follows)

Table B-40 (Continued)

ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

March 30, 1977

Dear Mr. Farrand:

As you noted in your letter of February 14 to Mr. John Quarles, the Agency is currently addressing the problem of natural sources of air pollution which may cause violations of the National Ambient Air Quality Standards (NAAQS) for photochemical oxidants and particulate matter in rural areas. EPA is receiving comments on its Interpretative Ruling and Advance Notice of Proposed Rulemaking issued on December 21, 1976. Public hearings also have been held to solicit comments on issues related to the review of new sources within non-attainment areas.

EPA is now reviewing the record to determine if changes to the Interpretative Ruling are appropriate and beginning the development of proposed regulations to implement the concepts set forth in the Advance Notice of Proposed Rulemaking. In the interim the Agency is developing two position papers to assist the States, on a case-by-case basis, until the formal rulemaking process is complete. These position papers will clearly describe the intent of EPA as well as provide guidance to the Regional Office and the State new source reviews in non-attainment areas.

The first of these draft position papers (attached) entitled, "Effectiveness of Organic Emission Control Programs as a Function of Geographic Location," deals with the geographic areas where hydrocarbon control programs, including the emission offset requirement, would be most effective in reducing ambient levels of photochemical oxidant (commonly referred to as the "circle concept"). This concept, outlined in the Advance Notice of Proposed Rulemaking and specifically discussed at a workshop on photochemical oxidants in Denver, Colorado, on February 8 and 9, 1977, suggests that there is little basis for requiring emission offsets for a major hydrocarbon point source in rural areas of the western United States which are remote from population centers. The rationale for this conclusion, based upon preliminary experimental and field tests, is that ozone is relatively insensitive to organic precursors at non-methane hydrocarbons/nitrogen oxides ($NMHC/NO_x$) ratios exceeding 30:1.

Applying this reasoning to oil shale tracts, for example, would indicate that new sources would be allowed to construct without the need of an emission offset to the extent that they are relatively removed from population centers. I would suggest that the appropriate Department of Interior staff work with the oil shale lessees and EPA Region VIII staff to determine the applicability of the specific oil shale projects to new source review requirements as set forth in the position paper.

I would point out that the above guidance does not require a State to approve a source which meets the criteria as set forth in the position paper, although it would be expected that a State would consider the EPA policy in their decision-making process. Since the Colorado Department of Health is the agency from which lessees of the Colorado oil shale tracts would receive a permit to construct, their administrative procedures would have to be followed.

The second position paper, which is in its final draft stages, deals with the problems of particulate matter violations in rural areas where natural causes are suspected of creating an air quality non-attainment situation. This paper would help to further clarify existing EPA regulations for State Implementation Plan Development (40 CFR 51.12(d)) in that ". . . data derived from measurements of existing ambient levels of pollutant may be adjusted to reflect the extent to which occasional natural or accidental phenomena, e.g., dust storms, forest fires, industrial accidents, demonstrably affected such ambient levels during the measurement period."

As outlined in the December 21, 1976, ANPRM, this policy would recognize the differences between violations of the National Ambient Air Quality Standards due to "fugitive dust" in urban and rural areas. New sources that wish to construct in rural areas should be allowed to do so without the need of an emission offset if they meet certain criteria. These include compliance with specified emission limitations and the assurance that the source's emission, plus "non-urban" background and the emissions from other stationary sources in the vicinity of the proposed location, would not cause violations of the NAAQS. "Non-urban" background is defined as the lowest measured annual average particulate concentration measured in the broad area where the new source will be located. This policy, as applied to oil shale development on Colorado Tract C-b, for example, would require (1) compliance with Colorado emission regulations, and (2) the use of 7.8 $\mu g/m^3$ (found in Oil Shale Tract C-b Annual Summary and Trends Report) particulate matter as the background concentration to be superimposed on the air

quality diffusion modeling results for the 24-hour and annual predicted concentrations which would then be compared against the applicable ambient air quality standard. Compliance with air quality change limitations in the prevention of significant deterioration regulations also would be required.

These position papers, as interim guidance for case-by-case determinations necessary prior to final rulemaking, will be out early this summer. The formal rulemaking processes to incorporate these policy statements and various other items into the current state implementation plan requirements, contained in the Federal Register, will not be completed before 1978.

I have asked Mr. Walter Barber, Deputy Assistant Administrator of the Office of Air Quality Planning and Standards, to keep the Department of the Interior informed as to our progress on those position papers. He will provide you a draft copy of the particulate matter policy statement as soon as it becomes available. In addition, as other material is developed on these issues, it will be provided for your review and comment.

If I can be of any further assistance, please do not hesitate to contact me.

Sincerely yours,

/s/ Barbara Blum

Acting Douglas M. Costle

Honorable Chris Farrand
Acting Assistant Secretary
Department of the Interior
Washington, D.C. 20240

Enclosure

bcc: Regional Administrator VIII

Prepared by:CPDD:DRDunbar:dgr:X497:500NCMDurham:3/11/77
Retyped per ETuerk:kam:3/16/77:50482:937W
Retyped pg 3:kam:3/23/77:50482:937W

GLOSSARY

acoustic sounder - instrument which measures inversion heights continuously by emitting an audio pulse and measuring the time for a return echo. The time of pulse travel is directly proportional to height to the top of the layer.

acoustic sounder signature - the recorded pattern indicating stability or instability.

adiabatic - expansion without gain or loss of heat.

advection - change in a parameter due to horizontal motion of the air.

ambient - surrounding atmospheric conditions.

ambient standards - indicate absolute ambient levels of pollution that cannot legally be exceeded in a specific region.

anabatic - of or pertaining to rising wind currents - upslope.

anemometer - instrument which measures the speed of the wind.

anomalies - abnormal variations.

anthropogenic - pertaining to the study of the origin of man.

AOSS - Area Oil Shale Supervisor's Office.

AQMA - Air Quality Maintenance Area - area within a state for which the possibility of exceeding NAAQS exists.

arsine - AsH_3, arsenic hydride gas.

aspiration - the removal of liquids or gases from space by suction.

atmospheric stability - measure of the degree to which the actual hydrostatic lapse rate deviates from the dry adiabatic lapse rate; stable (unstable) if more negative (less) than the dry adiabatic rate.

azimuth - horizontal angular easterly direction from a fixed reference direction (north) to a position or object.

background levels - measured absolute ambient levels existing prior to man-made development in an area. Measurements made at the C-b Tract during the two year environmental baseline period are defined to be background levels.

bivane - instrument for measuring resultant wind direction.

bivariate frequency distribution - frequency distribution of two interacting variables.

category I, II, III - State of Colorado ambient air pollution categories as defined in Table 2-7.

CFM - cubic feet per minute.

CFR - Code of the Federal Register.

CH_4 - methane.

class I, II, III - Federal Prevention-of-Significant-Deterioration air quality classes as defined in Table 2-7.

climatology - the science that deals with the average course or condition of the weather at a place over a period of years as exhibited by temperature, wind velocity, and precipitation.

CO - carbon monoxide.

coefficient of correlation - measure of the interdependence of two random variables; the coefficient ranges in value from -1 to +1, indicating perfect negative correlation at -1, absence of correlation at 0, and perfect positive correlation at +1.

Colorado Ambient Air Quality Standards - see Table 2-7.

conditions of approval - conditions imposed by the AOSS for approval of the Environmental Baseline Program.

confidence level - the degree of assurance that in repeated sampling of x percent of the confidence intervals of populations, the population means actually occur in the intervals x number of times. We have the assurance that the method used to obtain the mean is x percent reliable (that it can be expected to work x percent of the time) where x specifies the confidence level, e.g., x = 95 percent.

convective cell - circulation associated with vertical motion (and independent of adjacent cells).

correlation - the joint variation of 2 variables, neither of which is restricted by the experimenter.

curie - unit of radioactivity, the amount of any nuclide that undergoes exactly 3.7×10^{10} radioactive disintegrations per second.

db(A) - sound levels in decibels measured on the "A" scale of a standard sound level meter.

decibel - unit used to express the magnitude of a change in sound level.

diabatic - not adiabatic.

diffusion - spreading of a cloud of particles in a fluid as a result of turbulent eddies.

diurnal - pertaining to or occurring daily.

dose - the product of intensity and time.

dry adiabatic lapse rate - DALR - adiabatic lapse rate in dry air.

dry bulb temperature - air temperature.

emission standards - legal restrictions on the absolute amount or condition of release of a pollutant from any stationary or mobile source.

environmental baseline - environmental background levels as they exist during the two year Environmental Baseline Program.

environmental lease stipulations - stipulations as stated in the C-b Tract Prototype Oil Shale Leasing Program.

EPA - Environmental Protection Agency.

F Ratio - the value of a random variable having an F distribution; equals S_1^2/S_2^2 where S_1 and S_2 are the variances of independent random samples of size N_1 and N_2, respectively, taken from two normal populations having the same variance.

frontal passage - passage of a storm front.

generalized visibility - visual range averaged over all views.

gradient - maximum rate of change or slope.

hydrocarbons - an organic compound containing hydrogen and carbon.

H_2S - hydrogen sulfide.

industrial zone - applies to areas in which noise restrictions on industry are necessary to protect the value of adjacent properties for other economic activity excluding agricultural operations.

inversion - a state in which the air temperature increases with increasing altitude.

isobars - a line on a map connecting points of equal pressure.

isoline - line on a map connecting points of equal values of the parameter of interest.

isentropic - frictionless adiabatic process.

isopleths - contour levels of specified ground-level concentration of pollutant.

isotherms - a line on a map linking all points having identical mean temperature.

joint frequency distribution - a frequency distribution in two or more variables.

katabatic - downslope.

Langley - unit of temperature measurement equal to one gram calorie per square centimeter of irradiated surface.

lapse rate - variation in temperature (T) with increasing altitude (h) (dT/dh).

log - normal distribution - occurs whenever a random variable is encountered such that its logarithm has a normal distribution.

macroscale - abnormally large scale.

MESA - Mine Enforcement Safety Administration.

micron - unit of length equal to one-millionth (10^{-6}) of a meter.

millibars - mb - unit of measurement for atmospheric pressure. 1 mb $=10^3$ dynes per square cm.

MSL - Mean Sea Level.

MST - Mountain Standard Time.

multiple linear regression - describes the joint linear relationship of a single variable (Y) to several other variables (X_i) in the equation $Y = b_0 + b_1X_1 + b_2X_2 + b_3X_3 + \cdots + b_kX_k$.

NAAQS - National Ambient Air Quality Standards.

Newton - unit of force required to accelerate a mass of 1 kilogram one meter per second; it is equal to 100,000 dynes.

NMHC - non-methane hycrocarbons.

NO - nitric oxide.

NO_2 - nitrogen dioxide.

noise exposure - noise dose, the product of intensity x time.

noise intensity level - loudness or intensity of noise, usually in decibels.

noise pollution control standards - noise intensity as specified in Table 2-9.

normal distribution - a symmetrical, bell-shaped curve that describes the frequency distribution of most natural occurrences.

NOX - nitrogen oxides.

O_3 - ozone

orographic lifting - change in height of air parcel trajectories due to flow over mountains.

OSHA - Occupational Safety and Health Administration.

oxidant - product of photochemical oxidation or "smog," traditionally measured by the amount of ozone present.

particulates - suspended particles.

pc/m^3 - pico-curies per cubic meter.

photochemical - interactions of radiant energy and chemical systems.

photographic photometry - technique to determine visual range from the attenuation of light by atmospheric scattering.

pibal - untethered or pilot balloon.

potential temperature - temperature reached by dry adiabatic compression to 1000 mb from given initial temperature and pressure.

ppb - parts per billion.

precursors - prerequisites for ozone formation such as the presence of hydrocarbons and nitric oxide.

pre-exploration environmental investigation - environmental investigations on C-b Tract preceding the environmental baseline program.

Preliminary Development Plan - preliminary document of development and environmental plans written in 1974.

primary standards - air quality standards based on protection of public health.

pristine area - class I area.

PSD - Prevention of Significant Deterioration.

pyranometer - instrument that measures solar radiation.

regression - the consideration of frequency distributions of one variable when another is held at fixed levels.

relative humidity - the ratio of the amount of water vapor in the air at a specific temperature to the maximum capacity of the air at that temperature.

respirable - suspended particulates in the size range that enter the lungs.

secondary standards - air quality standards that are based on the protection of public welfare.

sector - portions of the area of a circle bounded by radii that are ±11.25 degrees from a cardinal compass-point direction.

side-by-side tests - two identical analyzers of the same constituent are placed adjacent to each other to test the accuracy of the analyzers.

SO_2 - sulfur dioxide.

sounding - measuring parameters during a vertical traverse.

stable layer - exists in atmosphere when the actual lapse rate is less negative than the dry adiabatic lapse rate; vertical diffusion of gaseous constituents is inhibited.

standard deviation of wind direction - the square root of the variance in wind direction.

standard error of the estimate - the standard deviation of the distribution of sample means.

stratum - horizontal atmospheric layer.

superadiabatic - hydrostatically unstable, i.e., vertical temperature gradient is more negative than dry adiabatic.

supplemental exploration plan - modified preliminary exploration plan, part of the Preliminary Development Plan.

synoptic - depicting weather conditions over a large area as they exist simultaneously.

tethersonde - tethered balloon.

THC - total hydrocarbons.

theodolite - a surveying instrument used to measure horizontal and vertical angles to an object; it utilizes a small telescope that can move in horizontal and vertical planes.

thermistor - a resistor made of semi-conductors having resistance that varies rapidly and predictably with temperature.

trough - an elongated region of low atmospheric pressure, often associated with a front.

TSP - total suspended particulates.

T value - relative measure of the contribution of an independent variable to the multiple regression equation, calculated as regression coefficient divided by its standard error.

$\mu g/m^3$ - micrograms per cubic meter.

unstable layer - exists in atmosphere when the actual hydrostatic lapse rate is more negative than the dry adiabatic lapse rate; diffusion proceeds freely in both horizontal and vertical directions.

variance - the mean of the sum of squares of deviations from the mean.

visibility - see generalized visibility.

visual range - the distance at which the contrast between an object and the horizon sky vanishes to the extent that the object is no longer visible.

vorticity - measure of angular rotation.

West-Gaeke - wet chemical method of determining ambient concentrations of gaseous constituents.

wet-bulb temperature - temperature to which air may be cooled by evaporating water into it at constant pressure until it is saturated.

wind rose - polar plot of frequency of wind direction (sometimes includes wind speed).

X/Q Estimate - ground-level pollutant concentration per unit pollutant emission.